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Sensitivity of Runway Occupancy Time (ROT) to Various Rollout and Turnoff (ROTO) Factors

Volume II - Complete Set of Plotted Data

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Contract NAS1-19703

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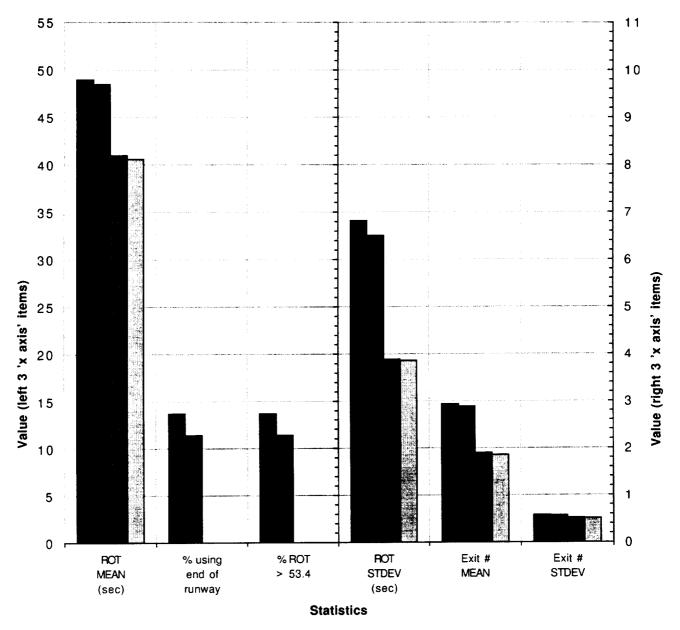
National Aeronautics and Space Administration Langley Research Center Hampton, Virginia 23681-0001

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1.	PLOTTED	ROT	SENSIT	IVITY	DATA		••••••	
2.	3-D ROT	DISPE	ERSION	& PF	ROBABILITY	DISTRIBUTION	GRAPHS.	4 9

■ MD-11; dry surface condition; Table data row 2

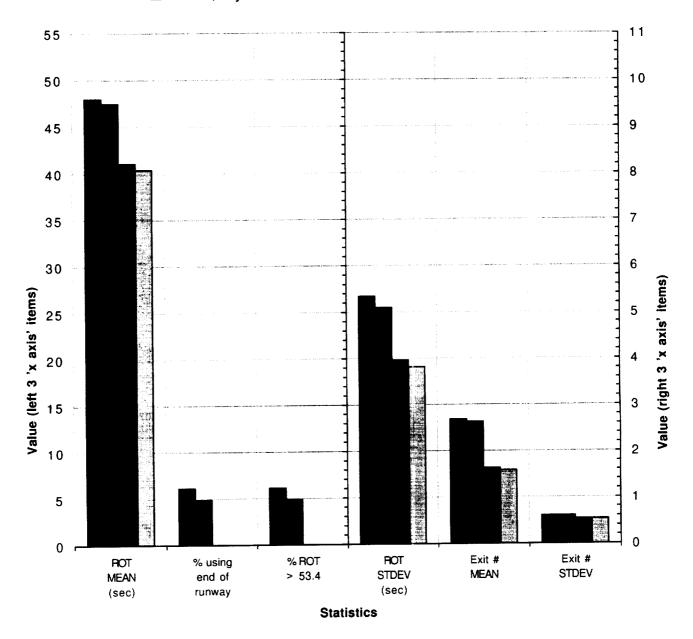
■ MD-81; dry surface condition; Table data row 4



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 4950

■ MD-11; dry surface condition; Table data row 7

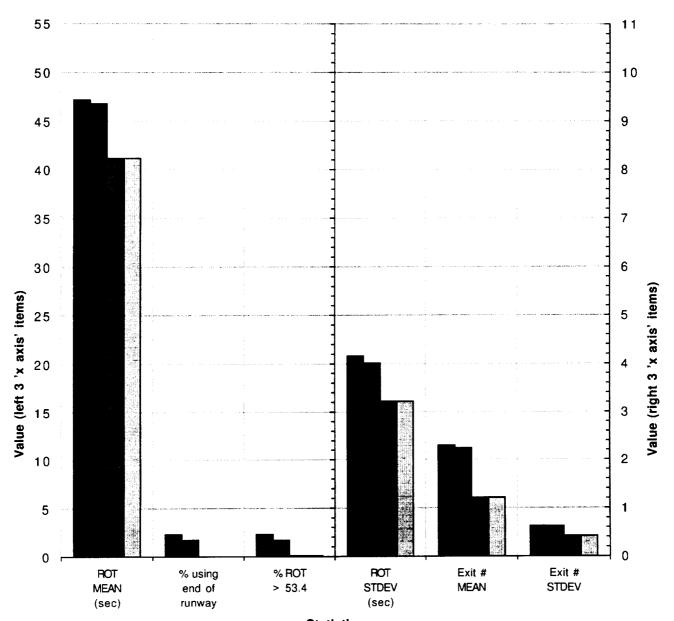
MD-81; dry surface condition; Table data row 9



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5350

■ MD-11; dry surface condition; Table data row 12

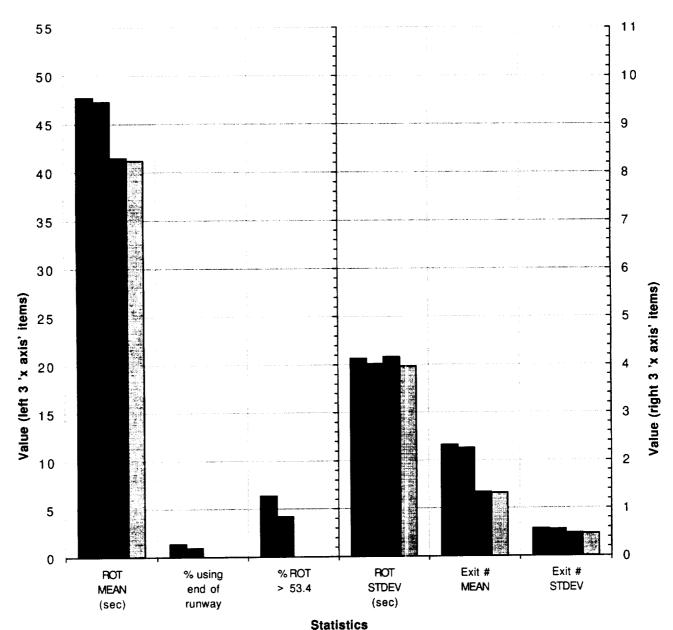
☐ MD-81; dry surface condition; Table data row 14



Statistics
Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 5950

■ MD-11; dry surface condition; Table data row 17

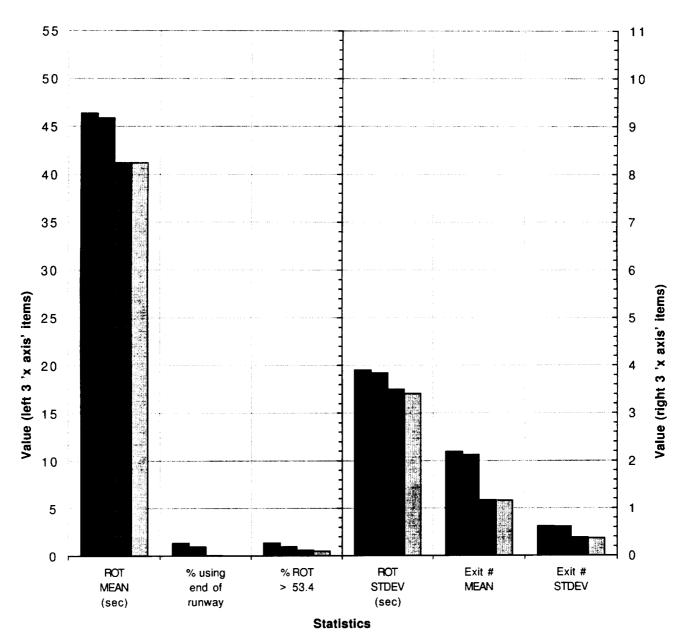
■ MD-81; wet surface condition; Table data row 18



Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 5950
wide exit separation

■ MD-11; dry surface condition; Table data row 22

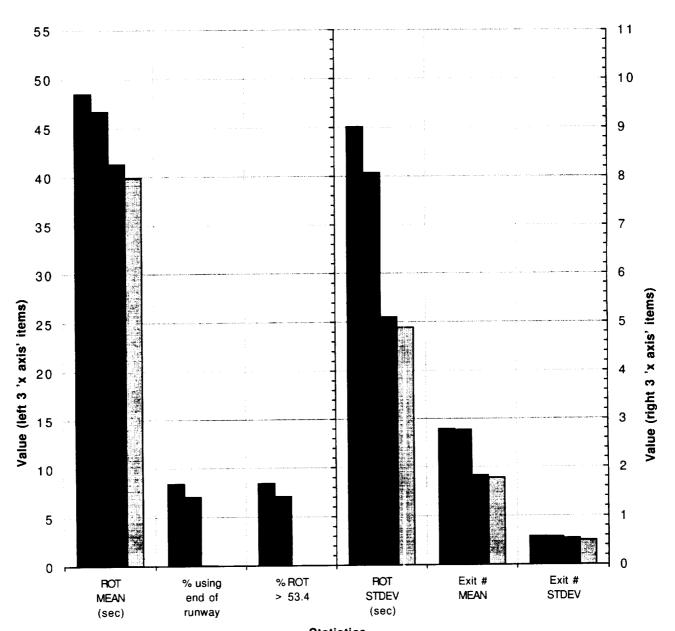
■ MD-81; dry surface condition; Table data row 24



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5950 full flaps

■ MD-11; dry surface condition; Table data row 27

MD-81; dry surface condition; Table data row 29



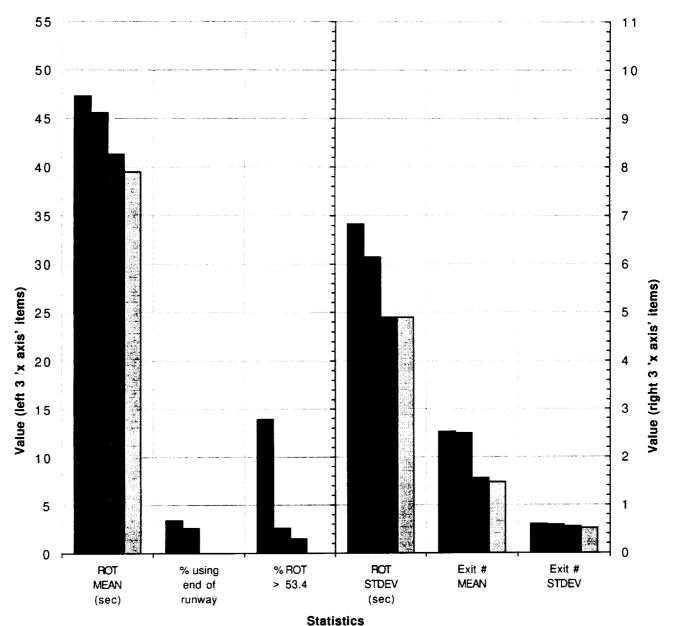
Statistics
Immediate med const reverse thrust & immed. const 6.5 decel

NO exit prediction

mid exit location = 4950

■ MD-11; dry surface condition; Table data row 32

■ MD-81; dry surface condition; Table data row 34



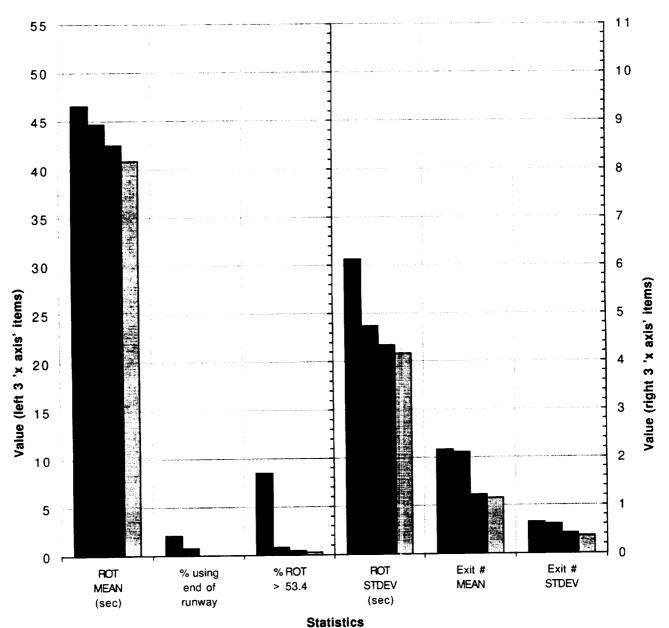
Immediate med const reverse thrust & immed const 6.5 decel

NO exit prediction

mid exit location = 5350

■ MD-11; dry surface condition; Table data row 37

■ MD-81; wet surface condition; Table data row 38



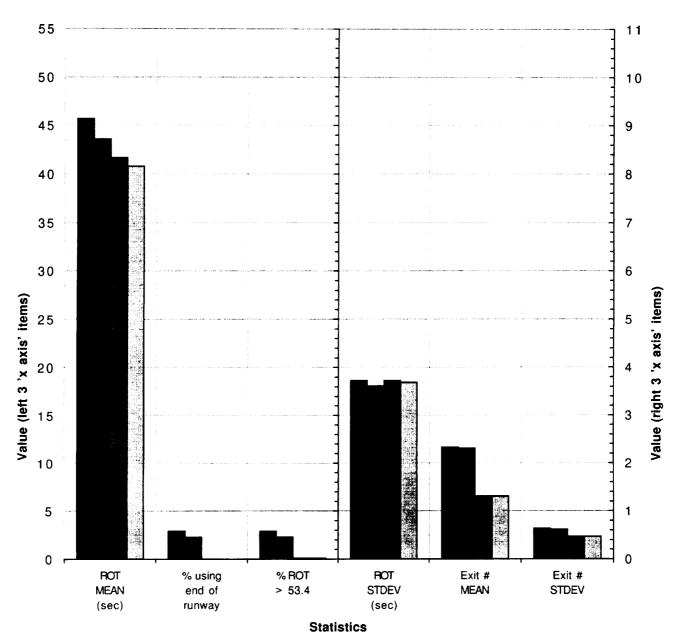
Immediate med const reverse thrust & immed. const 6.5 decel

NO exit prediction

mid exit location = 5950

■ MD-11; dry surface condition; Table data row 42

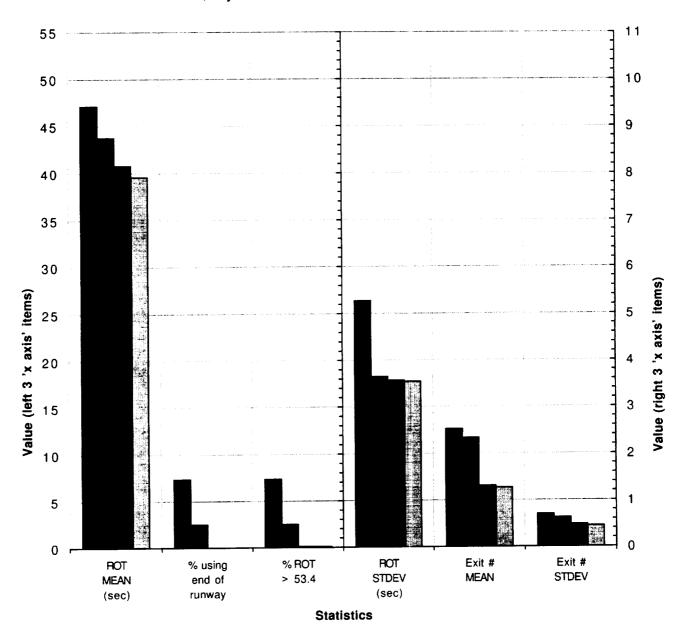
■ MD-81; wet surface condition; Table data row 43



Constant reverse thrust & roll-constant 6.5 decel with exit prediction mid exit location = 5950

■ MD-11; dry surface condition; Table data row 47

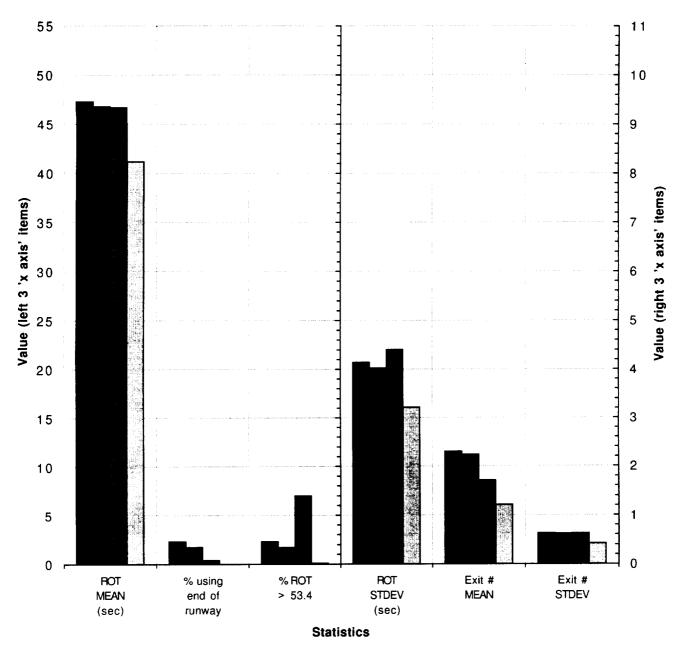
■ MD-81; dry surface condition; Table data row 49



Autoreverse thrust & roll-constant 6.5 deceleration with exit prediction mid exit location = 5950

■ MD-11; dry surface condition; Table data row 52

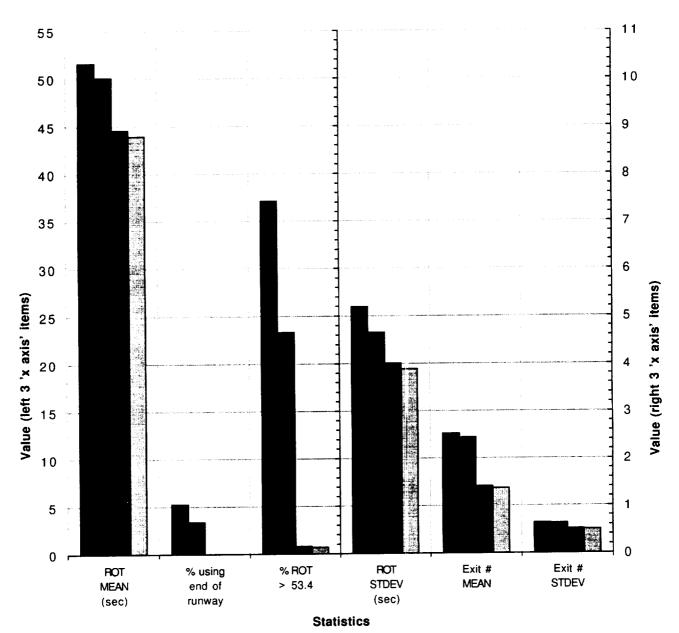
■ MD-81; wet surface condition; Table data row 53



Constant reverse thrust & variable deceleration with exit prediction mid exit location = 5950

■ MD-11; dry surface condition; Table data row 57

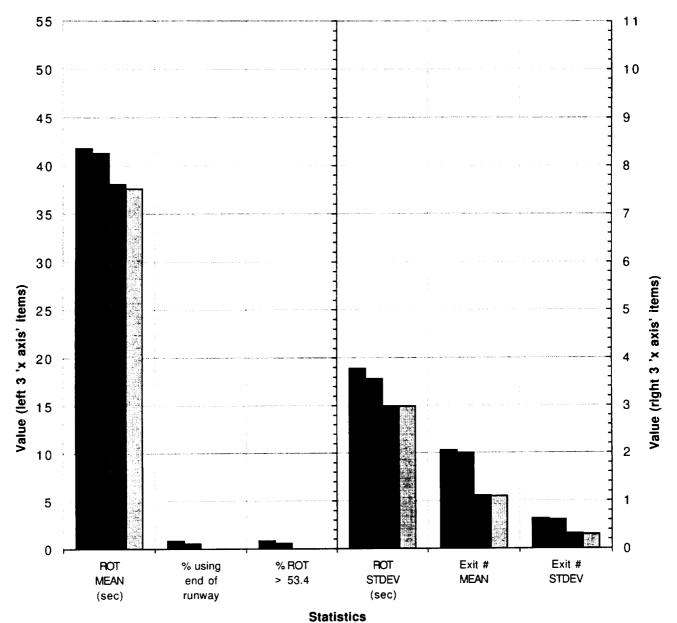
■ MD-81; wet surface condition; Table data row 58



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5950 60 knot exit speed

■ MD-11; dry surface condition; Table data row 62

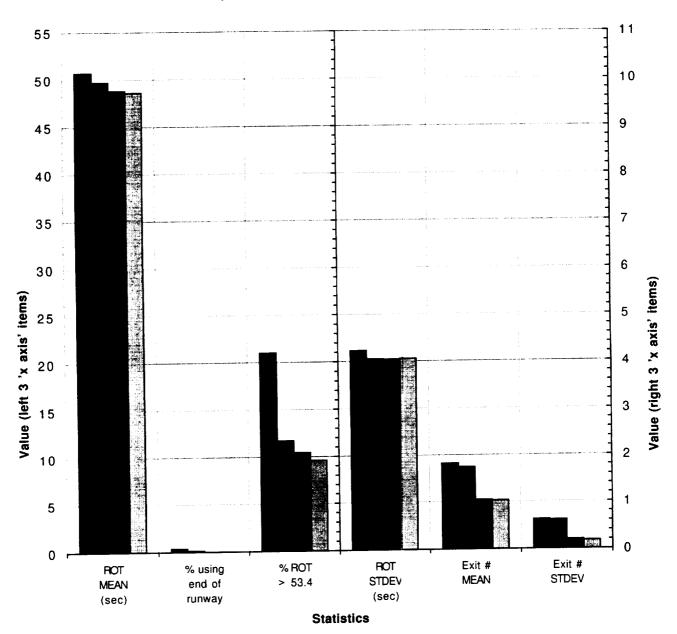
■ MD-81; dry surface condition; Table data row 64



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5950 80 knot exit speed

■ MD-11; dry surface condition; Table data row 67

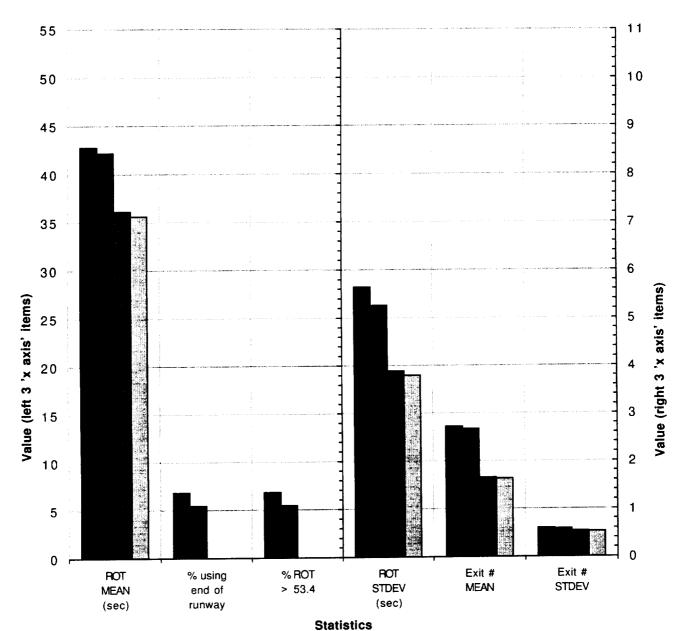
■ MD-81; wet surface condition; Table data row 68



Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 6950
60 knot exit speed

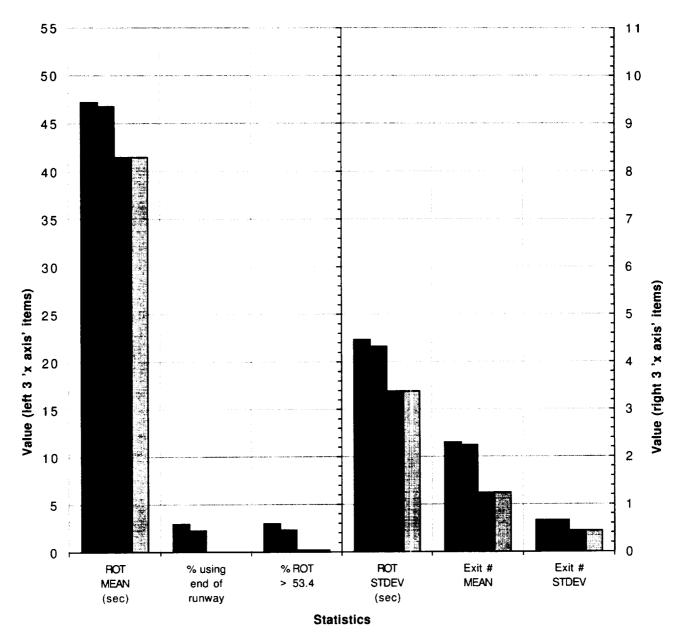
■ MD-11; dry surface condition; Table data row 72

■ MD-81; dry surface condition; Table data row 74



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 4950 80 knot exit speed

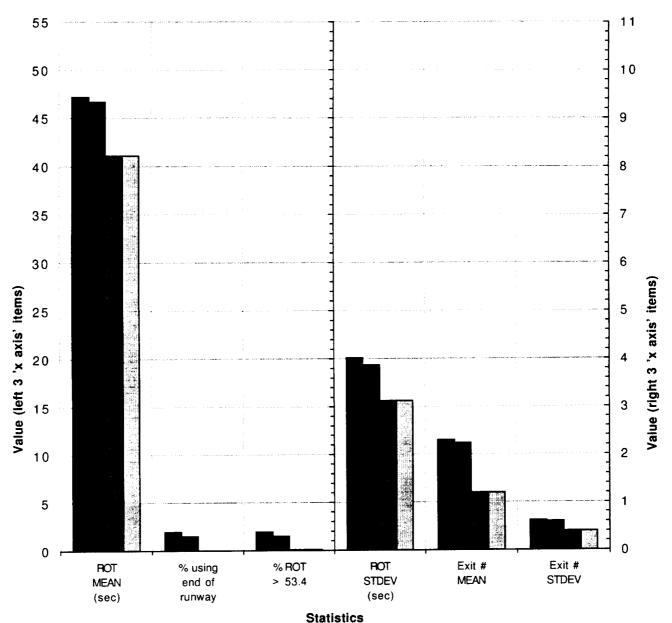
■ MD-11; dry surface condition; Table data row 77



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5950 TD dispersion sigma=375

■ MD-11; dry surface condition; Table data row 82

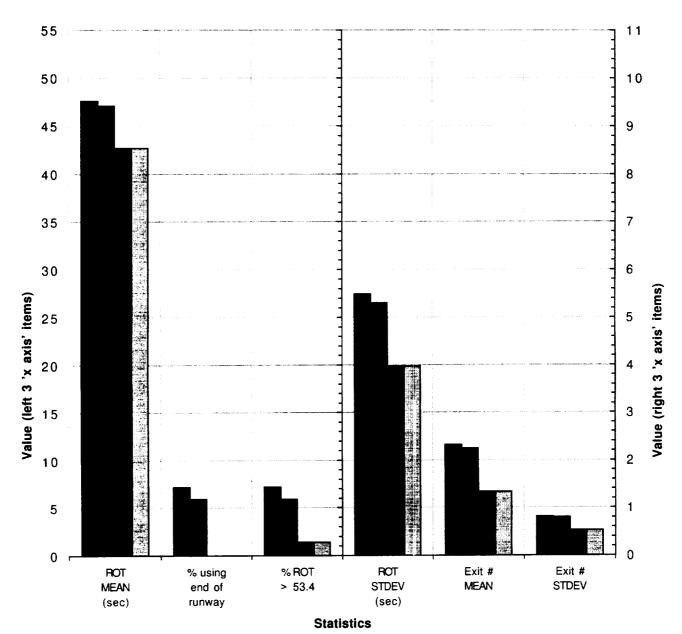
■ MD-81; wet surface condition; Table data row 83



Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 5950
TD dispersion sigma=100

■ MD-11; dry surface condition; Table data row 87

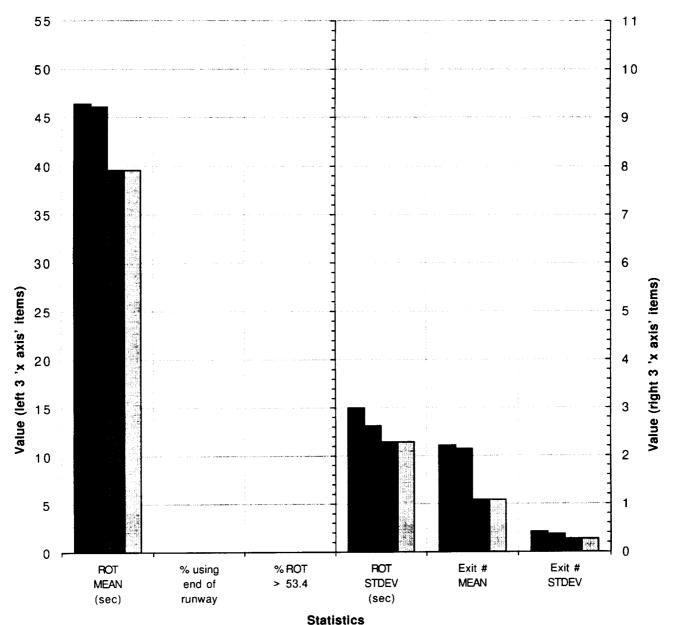
■ MD-81; wet surface condition; Table data row 88



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5950 TD gnd speed sigma=17

■ MD-11; dry surface condition; Table data row 92

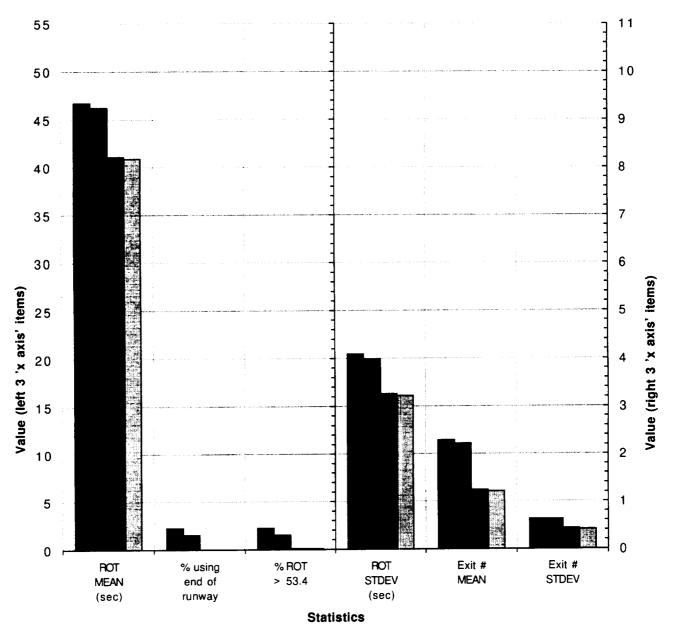
■ MD-81; dry surface condition; Table data row 94



Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 5950
TD gnd speed sigma=5

■ MD-11; dry surface condition; Table data row 97

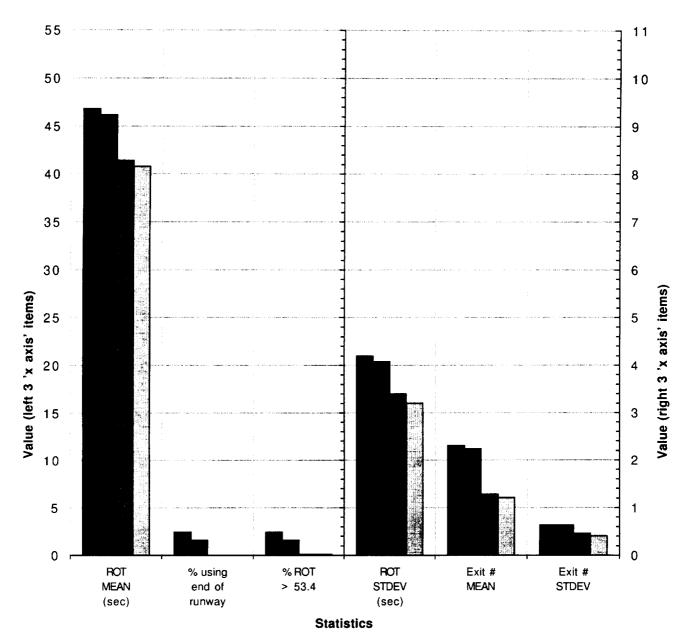
■ MD-81; wet surface condition; Table data row 98



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5950 no crosswind

■ MD-11; dry surface condition; Table data row 102

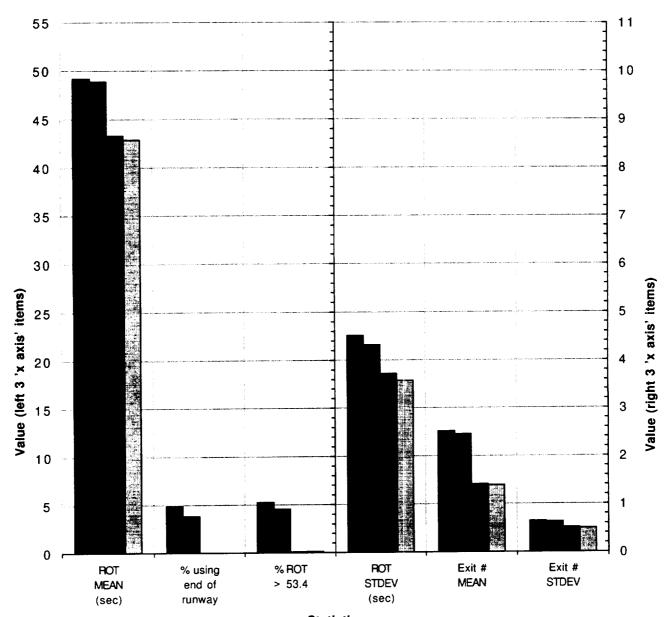
MD-81; dry surface condition; Table data row 104



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 5950 gusting crosswind 12.5 +2.5sigma, sensor noise

■MD-11; dry surface condition; Table data row 107

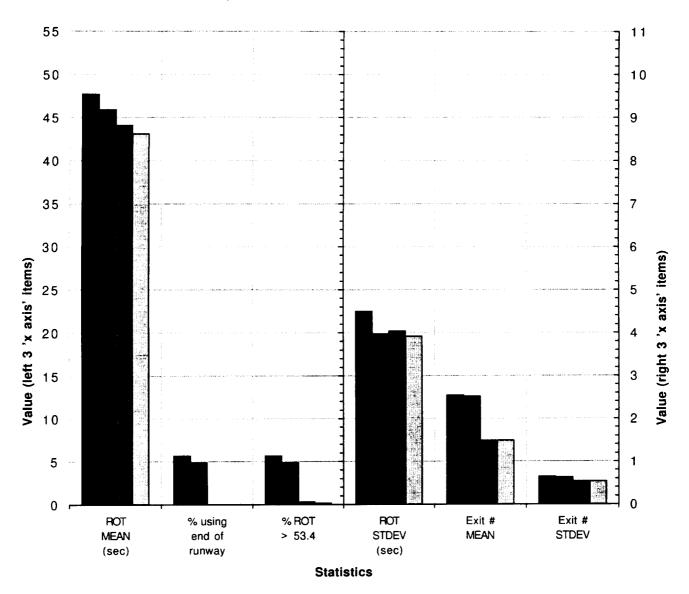
■ MD-81; wet surface condition; Table data row 108



Statistics
Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 5950
predict TD location error of 300 feet

■ MD-11; dry surface condition; Table data row 112

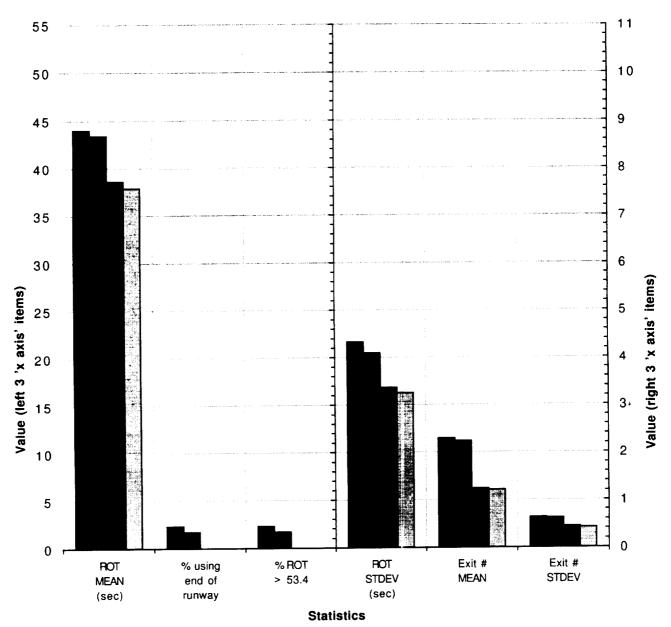
■ MD-81; dry surface condition; Table data row 114



Constant reverse thrust & roll-constant 6.5 deceleration with exit prediction mid exit location = 5950 predict TD location error of 300 feet

■ MD-11; dry surface condition; Table data row 117

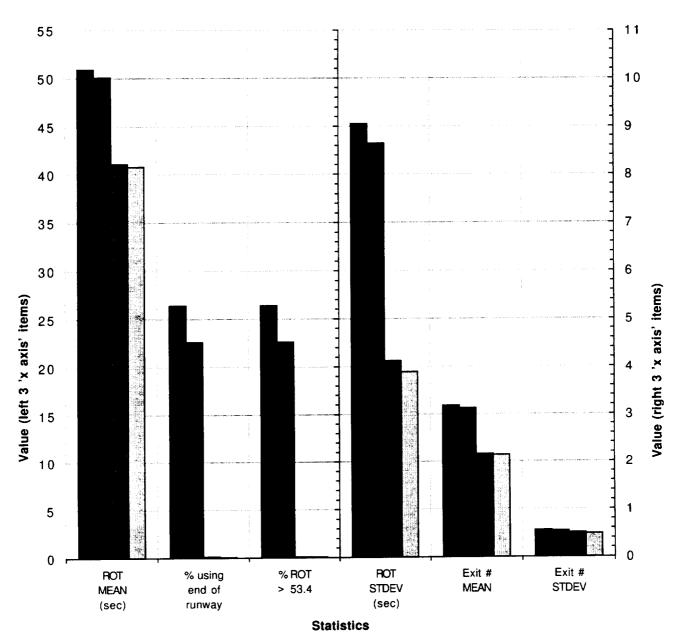
■MD-81; wet surface condition; Table data row 118



Autoreverse thrust & variable deceleration with exit prediction constant 2900 ft exit radius mid exit location = 5950

■ MD-11; dry surface condition; Table data row 122

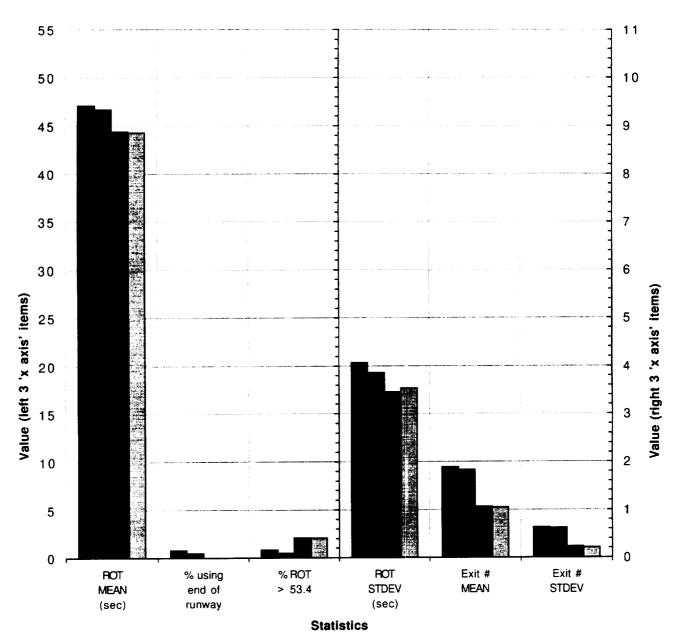
MD-81; dry surface condition; Table data row 124



Autoreverse thrust & variable deceleration with exit prediction mid exit location = 4550

■ MD-11; dry surface condition; Table data row 127

■ MD-81; wet surface condition; Table data row 128

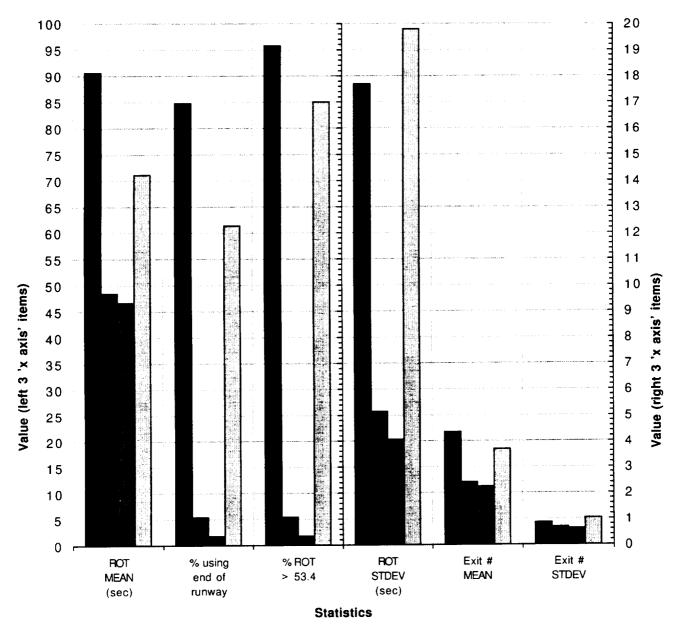


Autoreverse thrust & variable deceleration with exit prediction mid exit location = 6550

■ MD-11; snow surface condition; Table data row 132

■ MD-11; slush surface condition; Table data row 133

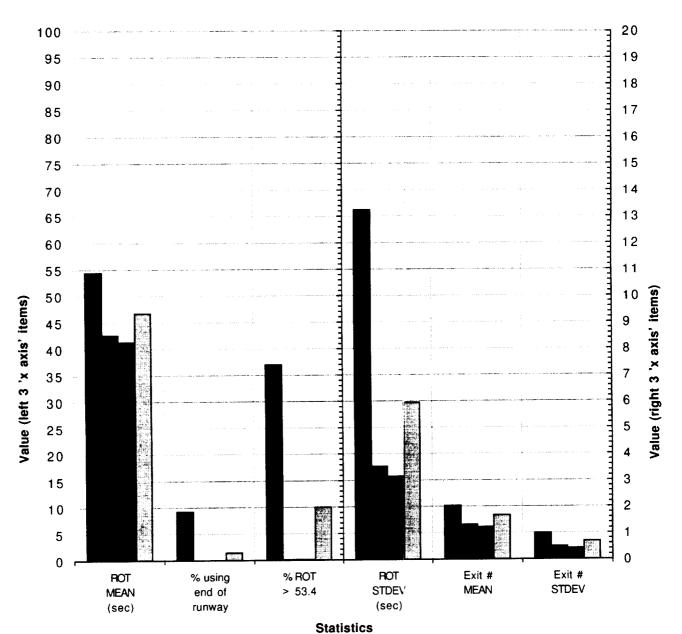
MD-11; flood surface condition; Table data row 134



MD-11 on various surface conditions
Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 5950

■MD-81; snow surface condition; Table data row 137

■MD-81; slush surface condition; Table data row 138



MD-81 on various surface conditions

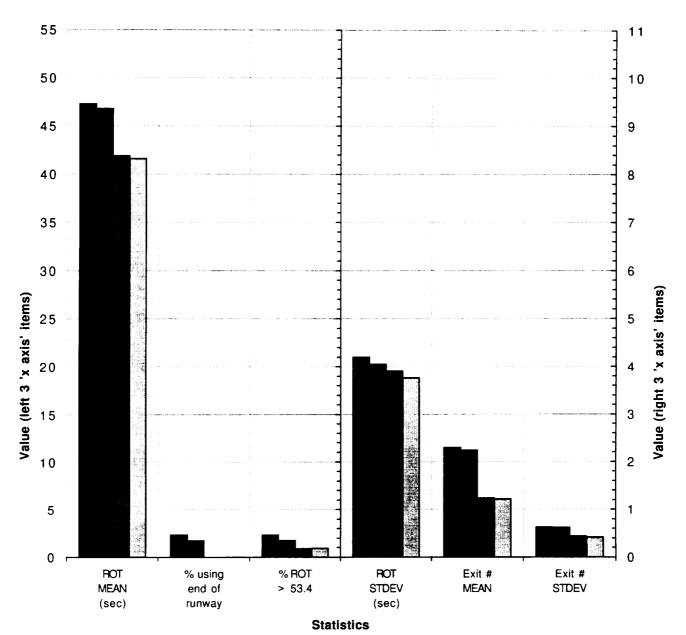
Autoreverse thrust & variable deceleration

with exit prediction

mid exit location = 5950

■ MD-11; dry surface condition; Table data row 142

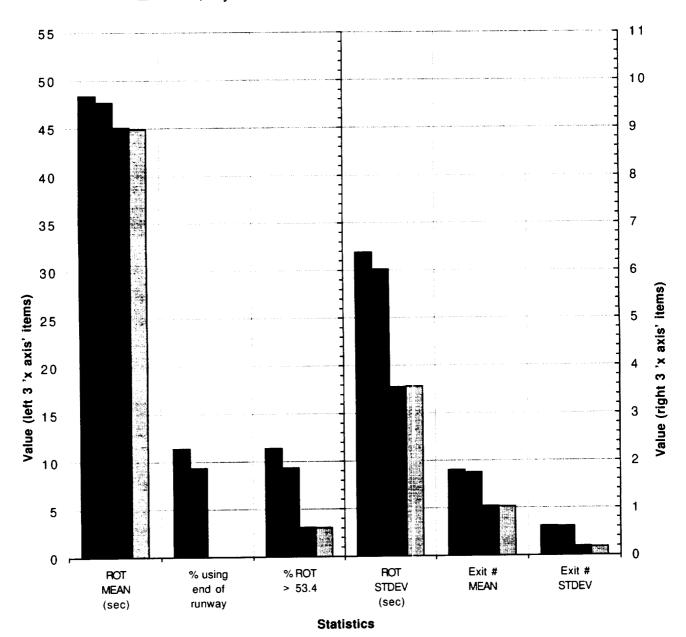
MD-81; dry surface condition; Table data row 144



Reverse Thrust not stowed, idle on exit
Autoreverse thrust & variable deceleration
with exit prediction
mid exit location = 5950

■ MD-11; dry surface condition; Table data row 147

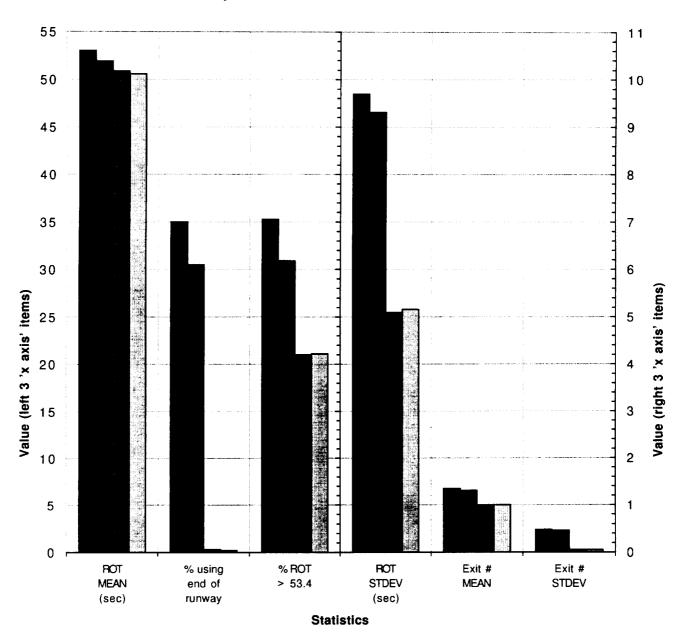
■ MD-81; wet surface condition; Table data row 148



2 high-speed exit locations at 5225 & 6650 feet Autoreverse thrust & variable deceleration with exit prediction

■ MD-11; dry surface condition; Table data row 152

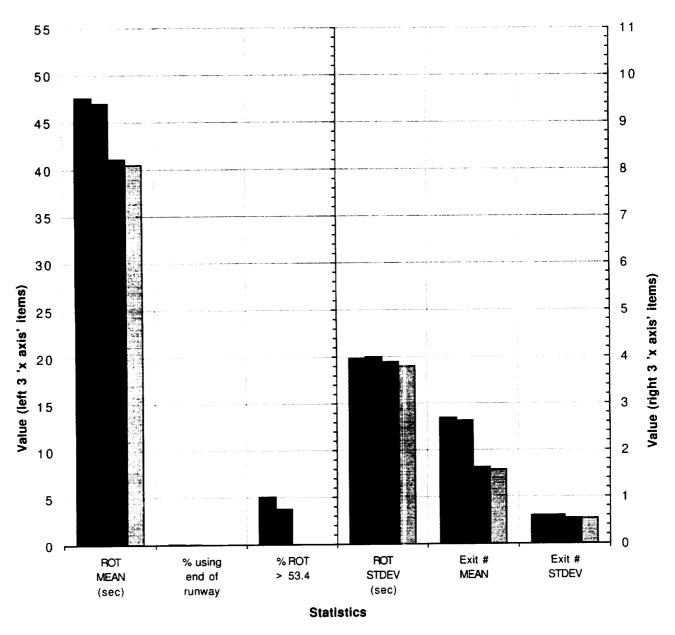
■MD-81; wet surface condition; Table data row 153



1 high-speed exit location at 5950 feet Autoreverse thrust & variable deceleration with exit prediction

■ MD-11; dry surface condition; Table data row 157

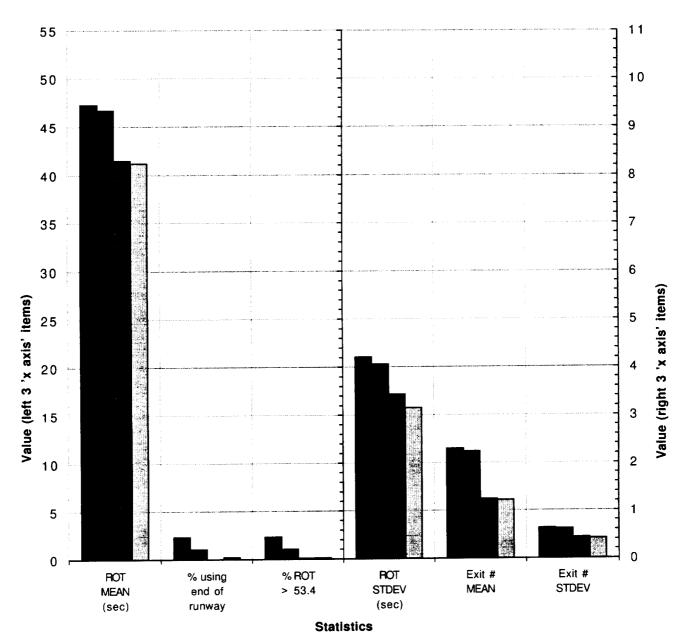
■ MD-81; wet surface condition; Table data row 158



4th high-speed exit location at 8300 feet with original mid exit location at 5350 feet Autoreverse thrust & variable deceleration with exit prediction

■ MD-11; dry surface condition; Table data row 162

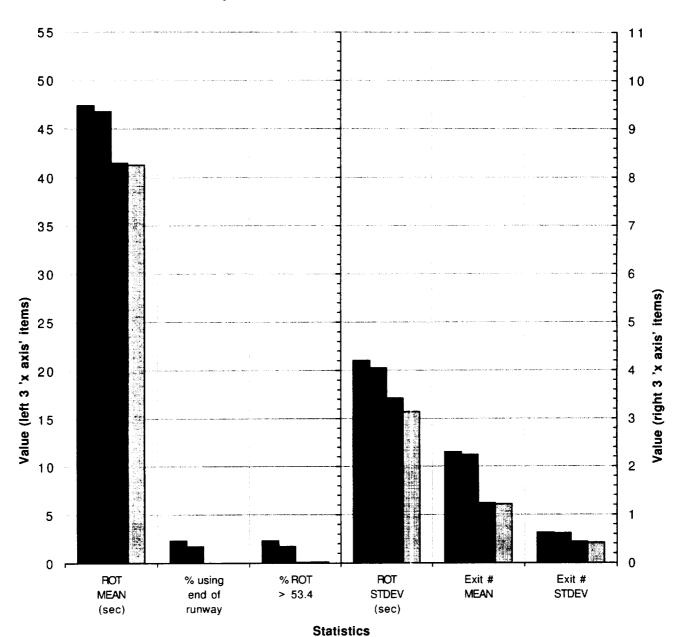
MD-81; dry surface condition; Table data row 164



Lateral touchdown offset of Y=27 feet mid exit location at 5950 Autoreverse thrust & variable deceleration with exit prediction

■ MD-11; dry surface condition; Table data row 167

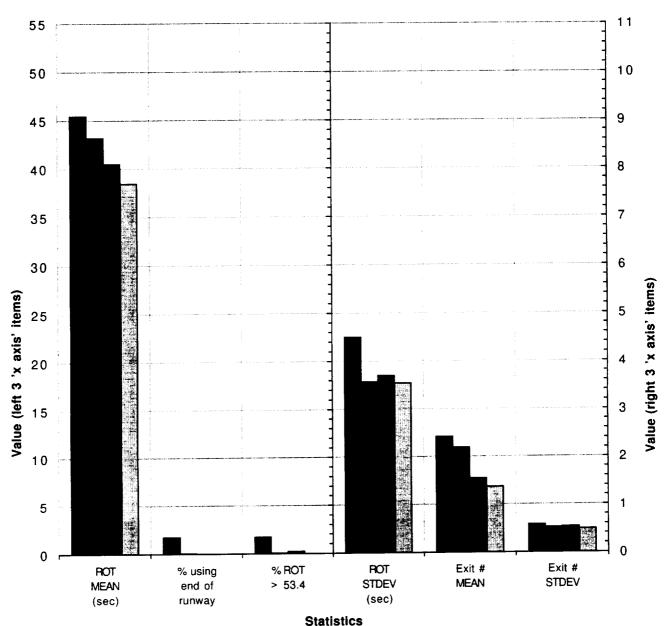
■ MD-81; wet surface condition; Table data row 168



Aircraft CG stop on exit at Y≔480 feet
mid exit location at 5950 feet
Autoreverse thrust & variable deceleration
with exit prediction

■ MD-11; dry surface condition; Table data row 172

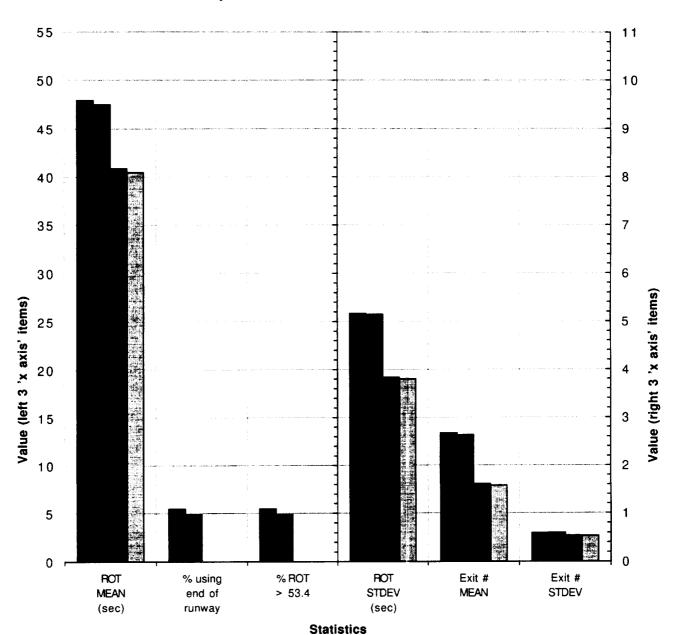
MD-81; dry surface condition; Table data row 174



Allow for a maximum deceleration of 9 ft/s/s
mid exit location at 5350 feet
Autoreverse thrust & variable deceleration
with exit prediction

■ MD-11; dry surface condition; Table data row 177

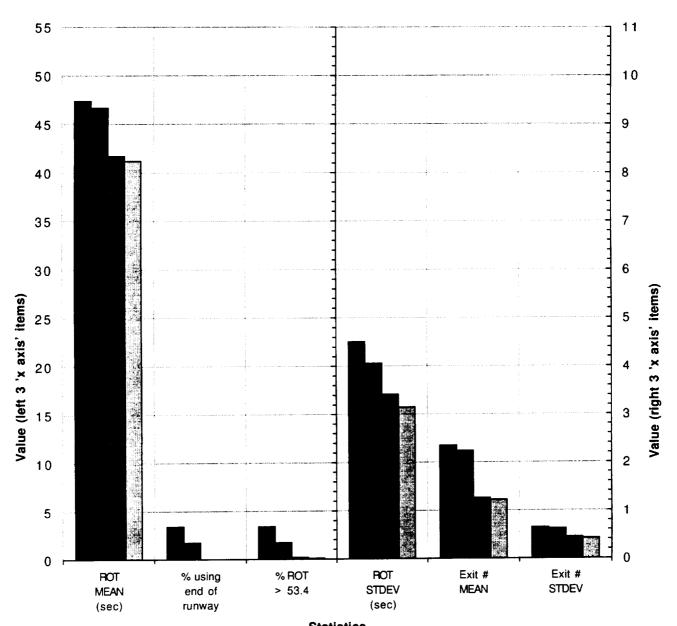
■ MD-81; wet surface condition; Table data row 178



Anti-skid efficiency equals 90% mid exit location at 5350 feet
Autoreverse thrust & variable deceleration with exit prediction

■ MD-11; dry surface condition; Table data row 182

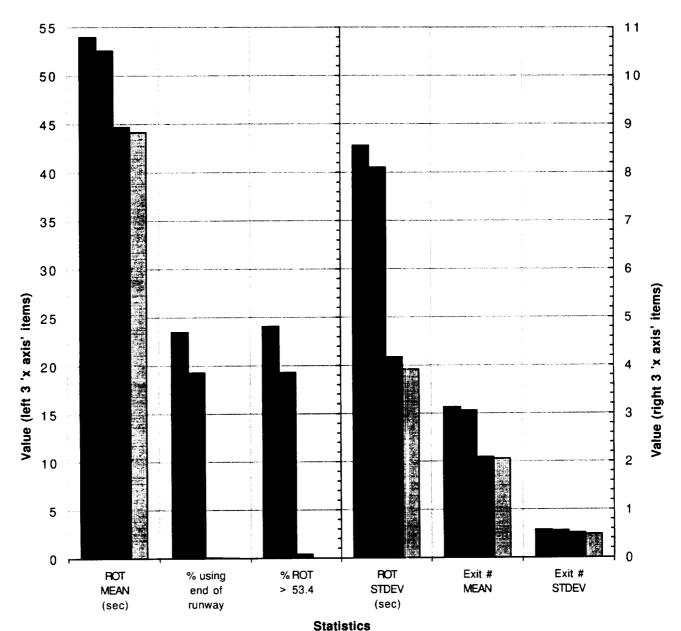
■ MD-81; wet surface condition; Table data row 183



Statistics
Anti-skid efficiency equals 60%
mid exit location at 5950 feet
Autoreverse thrust & variable deceleration
with exit prediction

■ MD-11; dry surface condition; Table data row 187

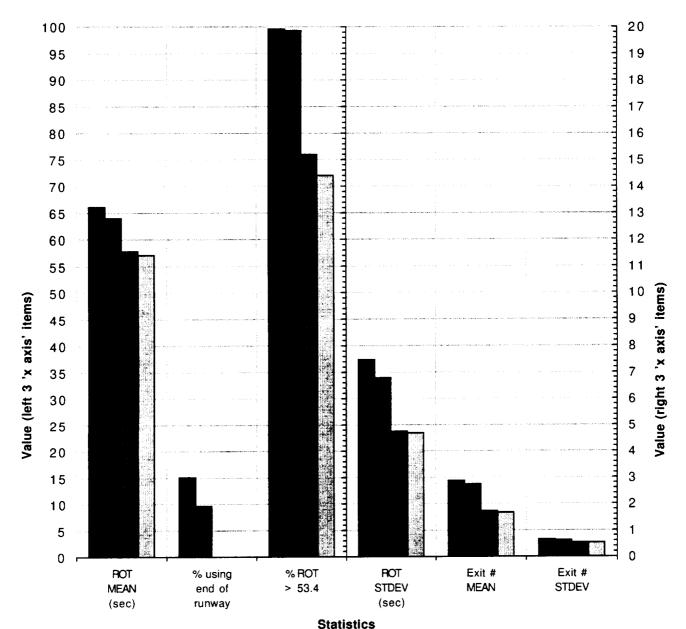
■ MD-81; dry surface condition; Table data row 189



Autoreverse thrust & variable deceleration with exit prediction mid exit location at 4950 feet 60 kt exit entrance speed

■ MD-11; dry surface condition; Table data row 192

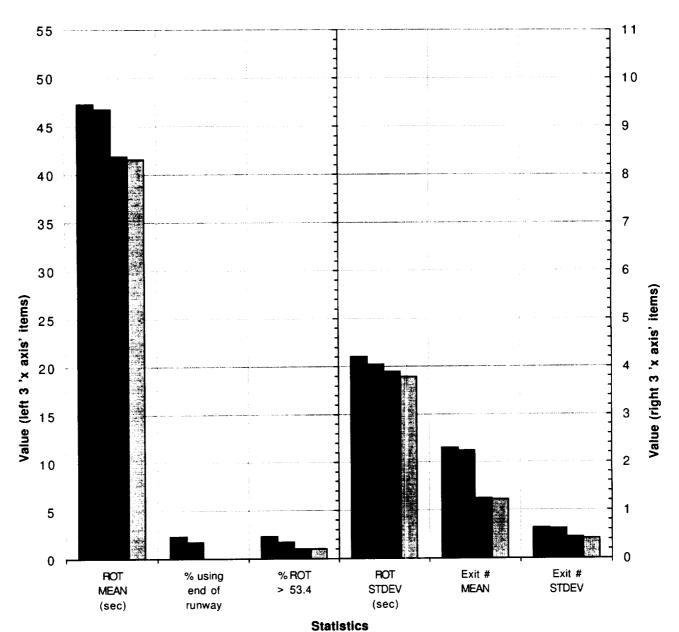
■ MD-81; dry surface condition; Table data row 194



Autoreverse thrust & variable deceleration with exit prediction mid exit location at 5950 feet 40 kt exit entrance speed

■ MD-11; dry surface condition; Table data row 197

■ MD-81; wet surface condition; Table data row 198



Reverse Thrust not stowed on exit

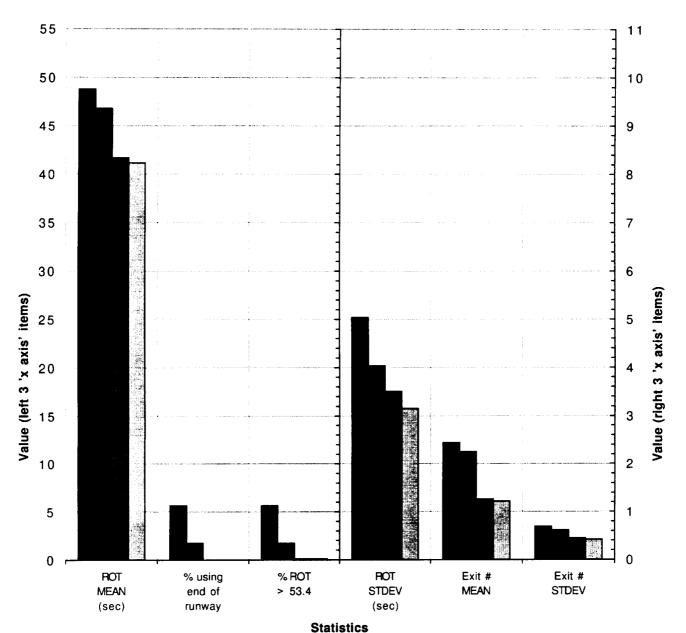
Autoreverse thrust & variable deceleration

with exit prediction

mid exit location at 5950 feet

■ MD-11; dry surface condition; Table data row 202

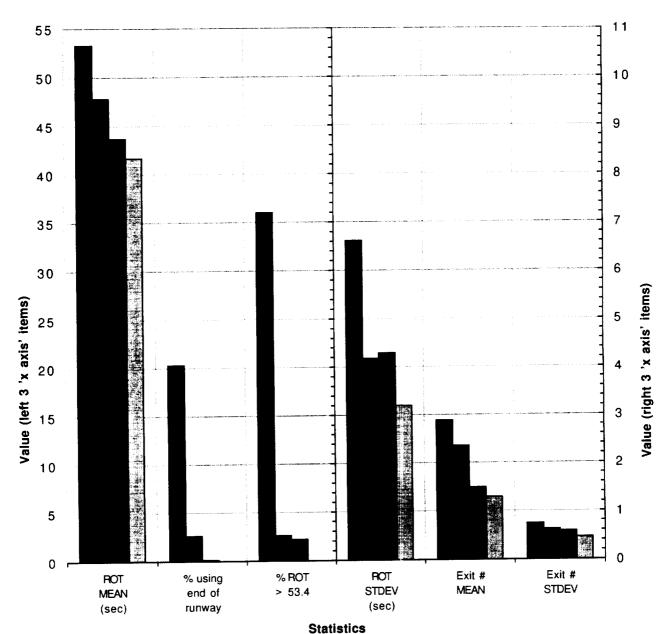
■ MD-81; wet surface condition; Table data row 203



Reverse Thrust Idle on Runway
Autoreverse thrust & variable deceleration
with exit prediction
mid exit location at 5950 feet

■ MD-11; dry surface condition; Table data row 207

■ MD-81; wet surface condition; Table data row 208



NO Reverse Thrust

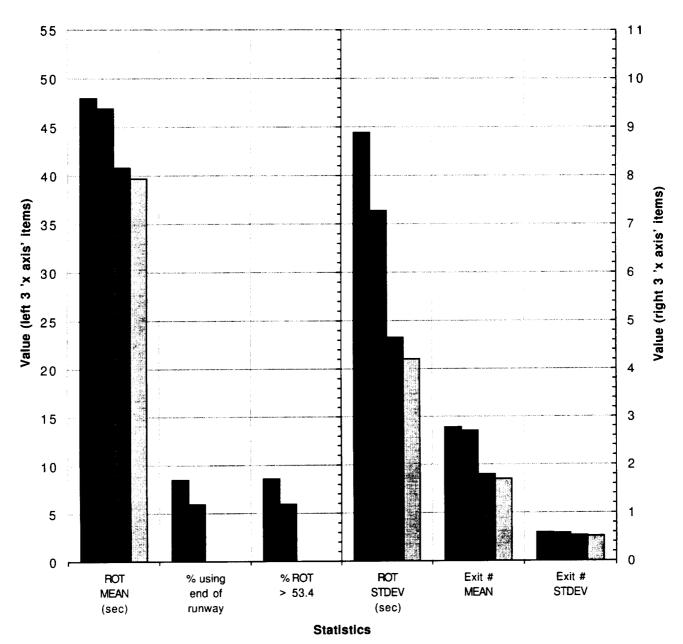
Autoreverse thrust & variable deceleration

with exit prediction

mid exit location at 5950 feet

■ MD-11; dry surface condition; Table data row 212

■ MD-81; wet surface condition; Table data row 213



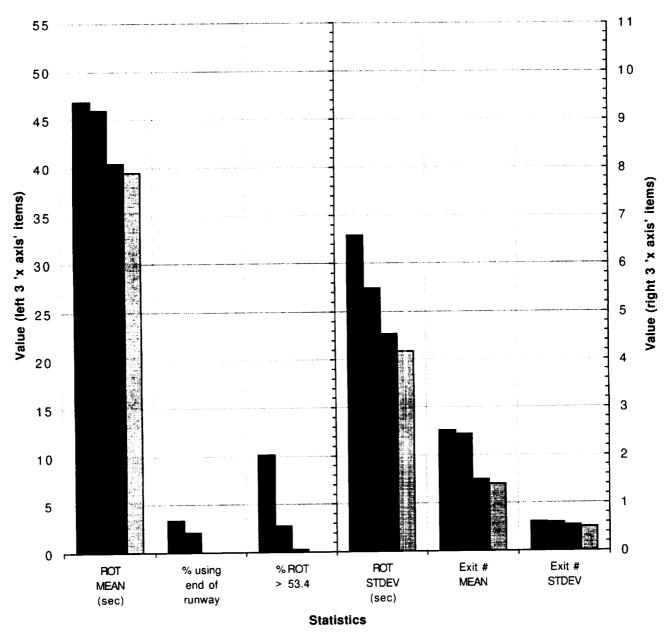
Immediate max const reverse thrust & immed. const 6.5 decel

NO exit prediction

mid exit location = 4950

■ MD-11; dry surface condition; Table data row 217

■ MD-81; wet surface condition; Table data row 218



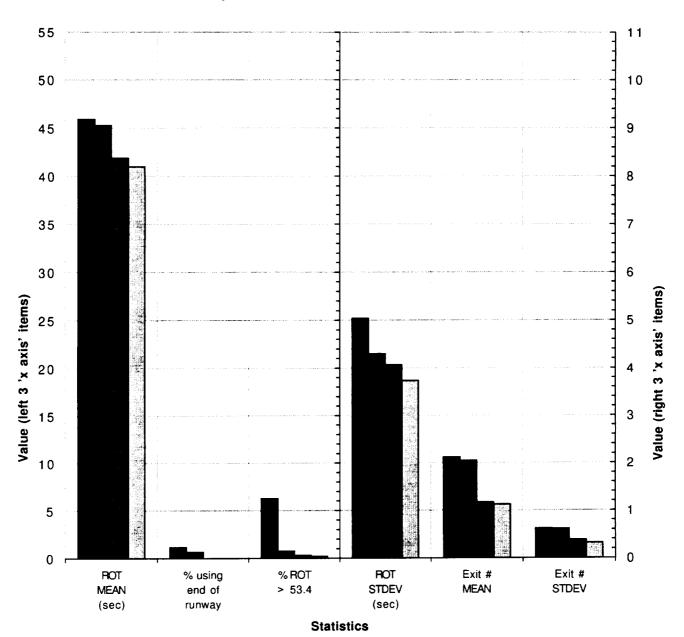
Immediate max const reverse thrust & immed. const 6.5 decel

NO exit prediction

mid exit location = 5350

■ MD-11; dry surface condition; Table data row 222

■ MD-81; dry surface condition; Table data row 224



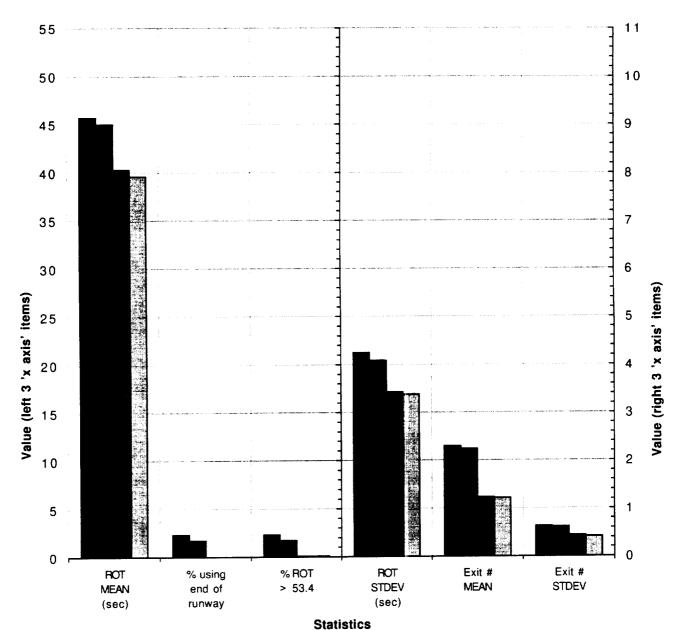
Immediate max const reverse thrust & immed. const 6.5 decel

NO exit prediction

mid exit location = 5950

■ MD-11; dry surface condition; Table data row 227

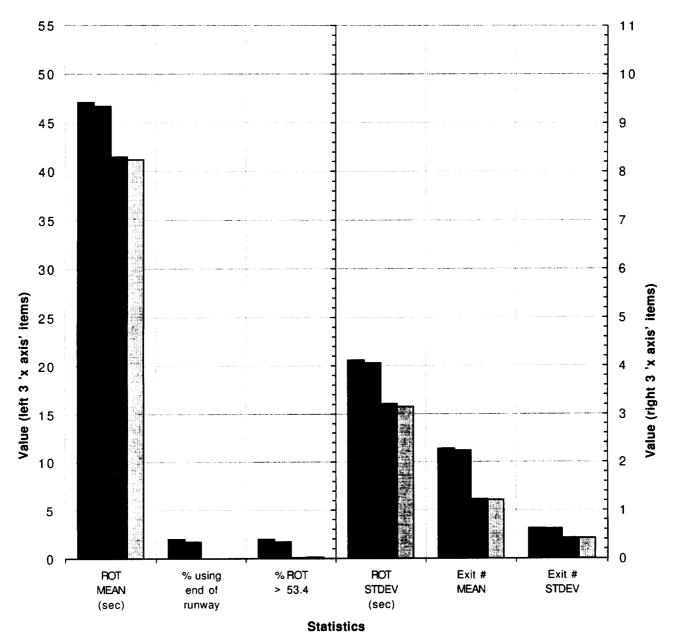
■MD-81; dry surface condition; Table data row 229



Auto asymmetric braking on exit
Auto reverse thrust/variable braking
with exit prediction
mid exit location = 5950

■ MD-11; dry surface condition; Table data row 232

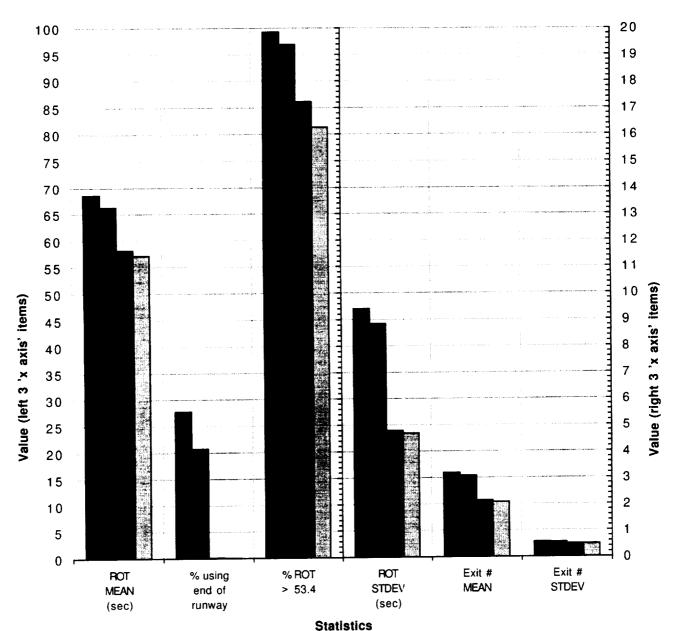
MD-81; dry surface condition; Table data row 234



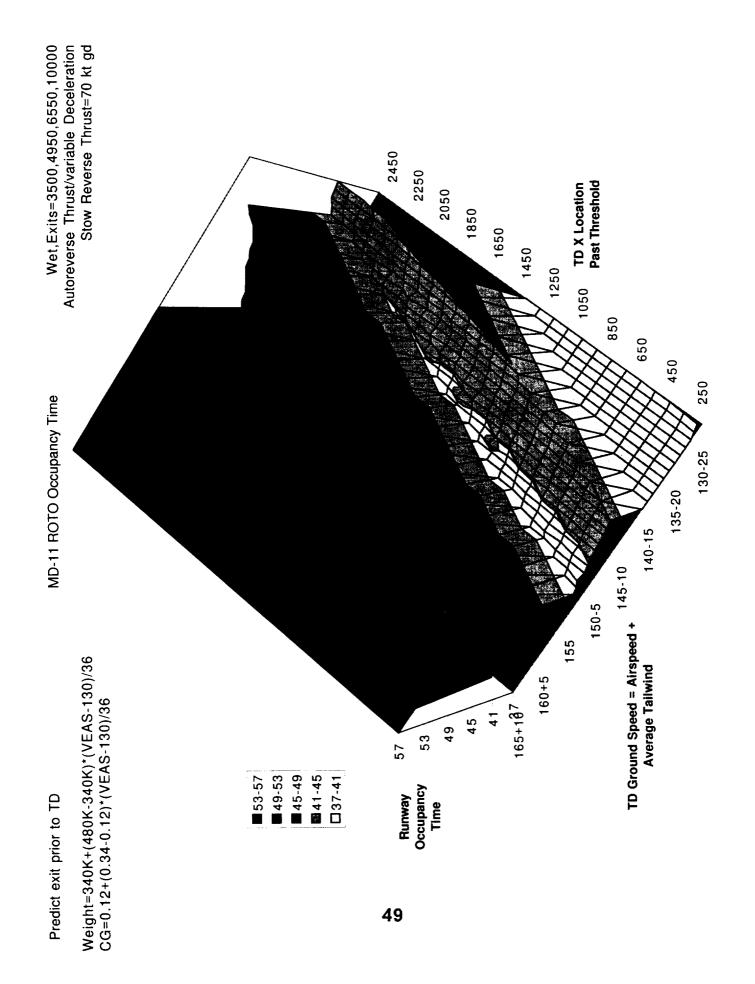
Anti-skid efficiency equals 90%
Mid exit location at 5950 feet
Autoreverse thrust & variable deceleration
with exit prediction

■ MD-11; dry surface condition; Table data row 237

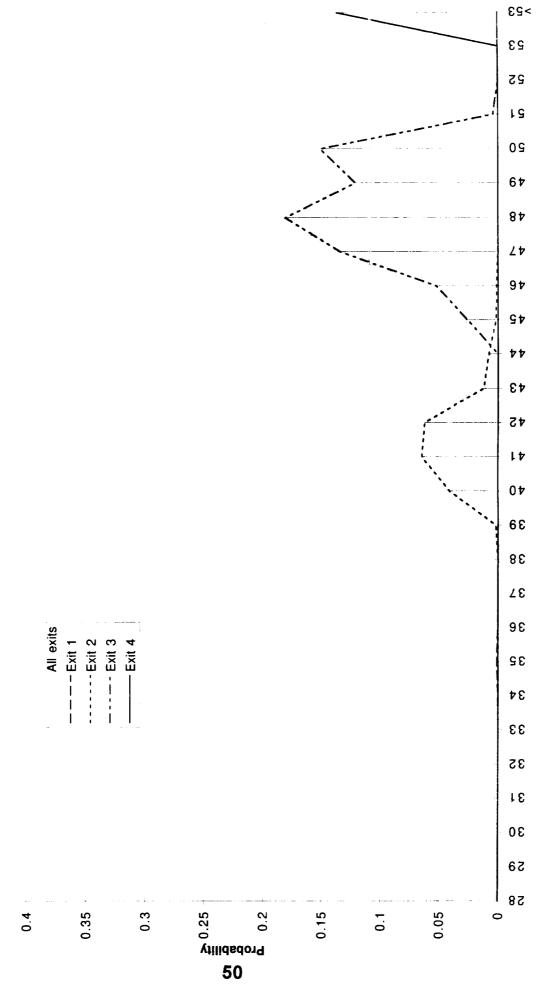
■ MD-81; wet surface condition; Table data row 238



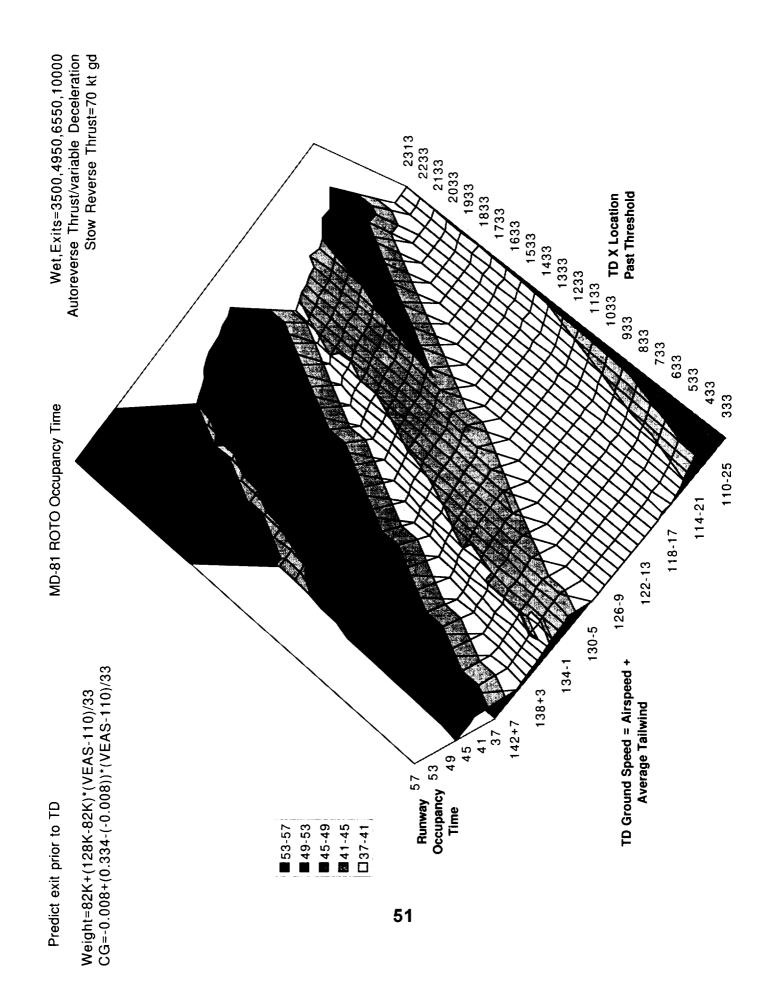
Autoreverse thrust & variable deceleration
with exit prediction
Mid exit location at 5350 feet
40 kt exit entrance speed



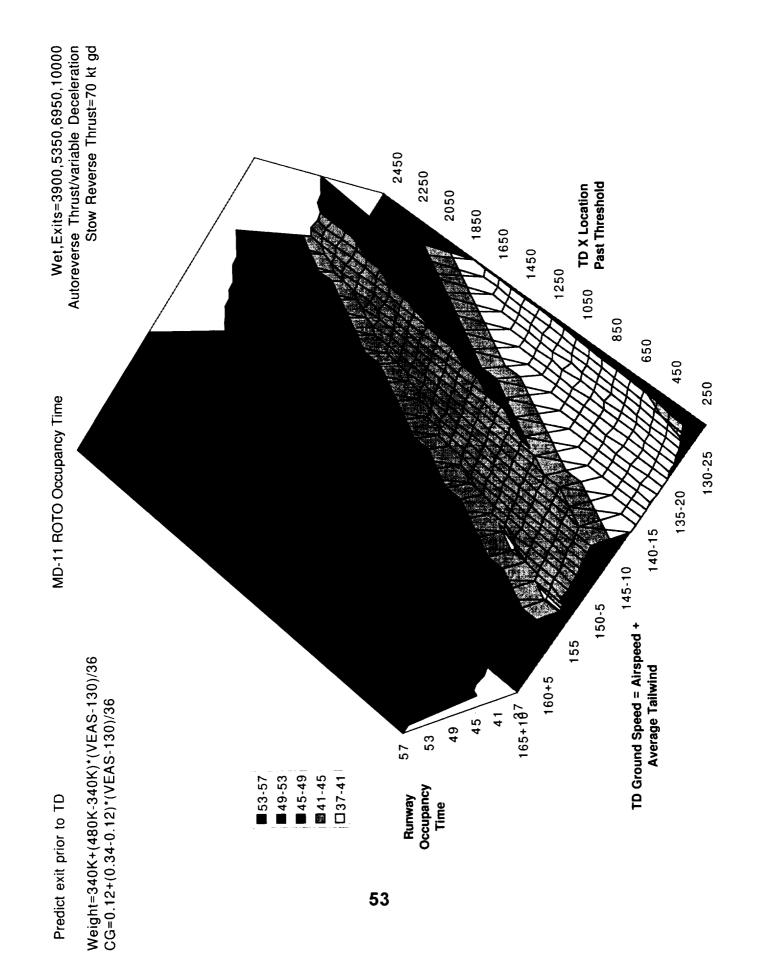
MD-11 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel Mean=49, STDEV=6.82



MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3500, 4950, 6550 & 10000 feet



>23 53 25 19 09 6*†* All Exits - Exit 4 ---Exit 1 ----- Exit 2 ---- Exit 3 81 L Þ MD-81 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3500, 4950, 6550 & 10000 feet 91 MD-81 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel Mean=41, STDEV=3.89 £ 7 45 17 0 t 38 86 3 2 98 32 34 33 35 18 30 58 82 Villidedora Si 0.15 0.05 0 0.3 0.35 0.45 0.1 0.4



MD-11 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel Mean=48, STDEV=5.34

All Exits

0.4

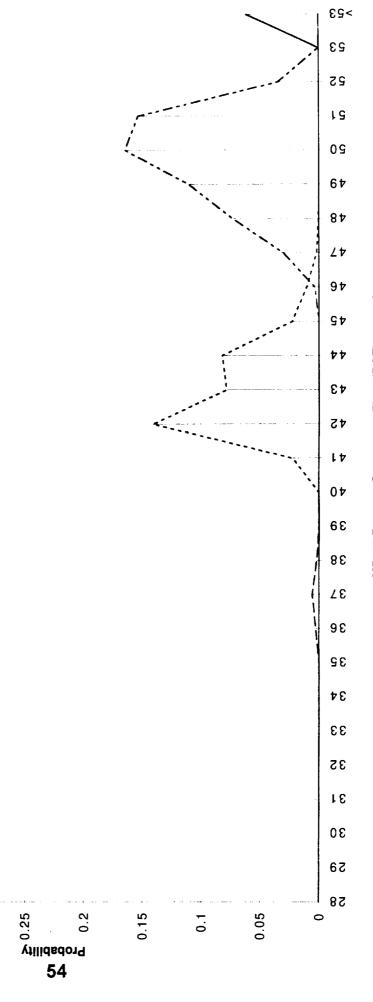
- Exit 4

----- Exit 2

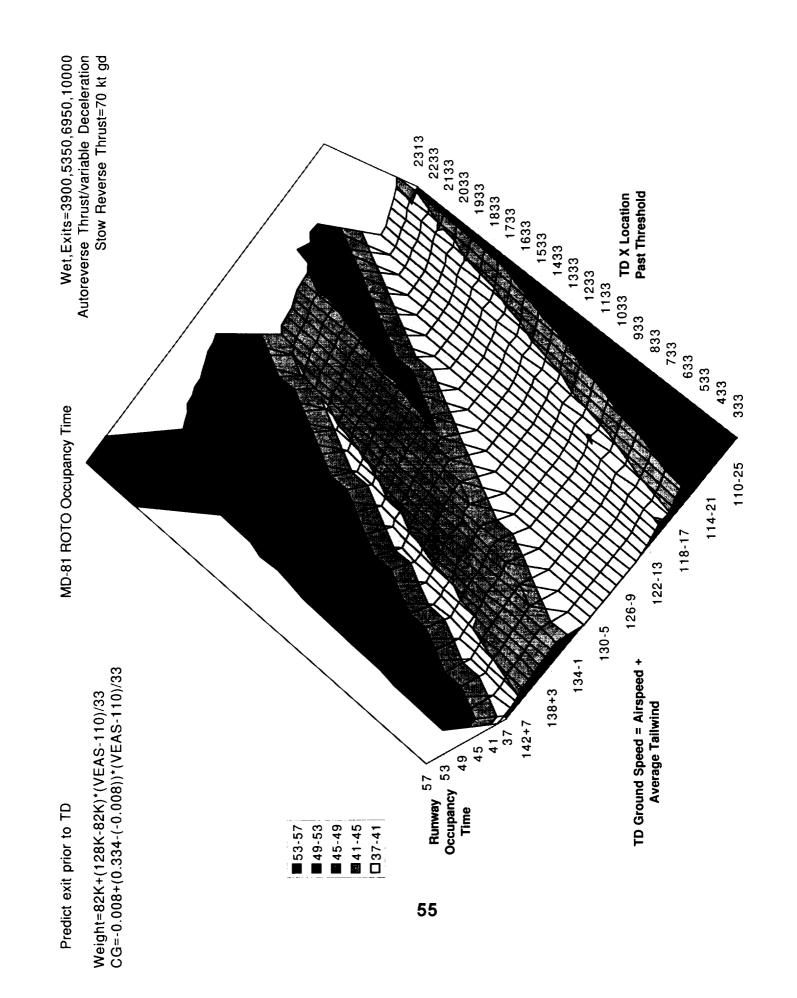
0.35

0.3

--Exit 1

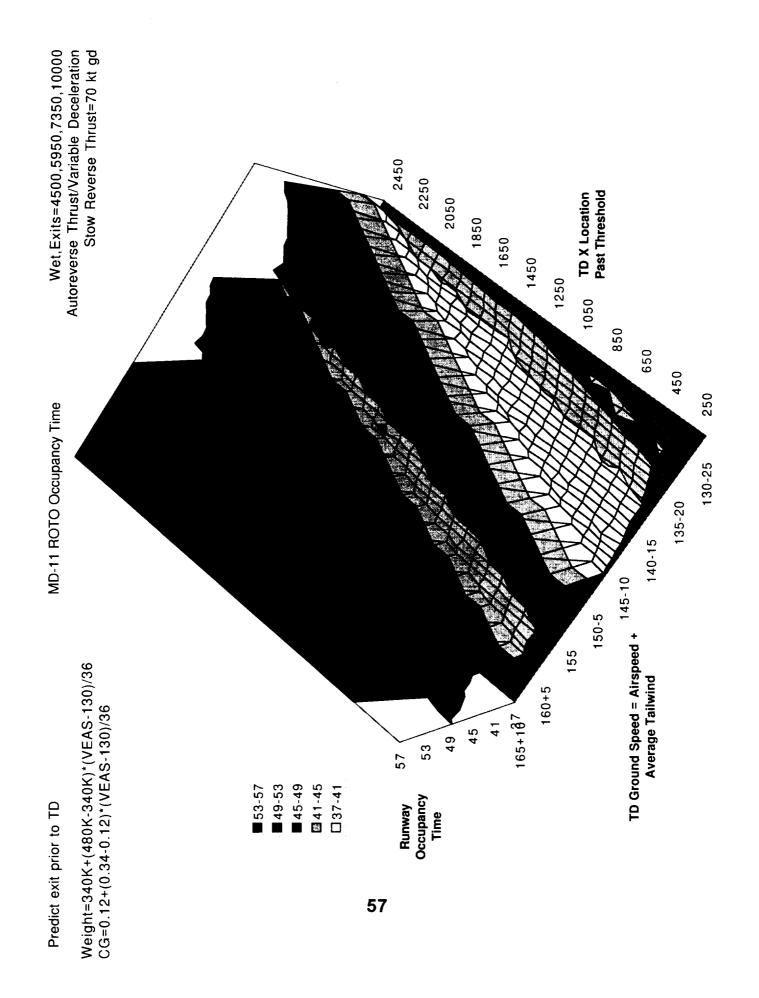


MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3900, 5350, 6950 & 10000 feet

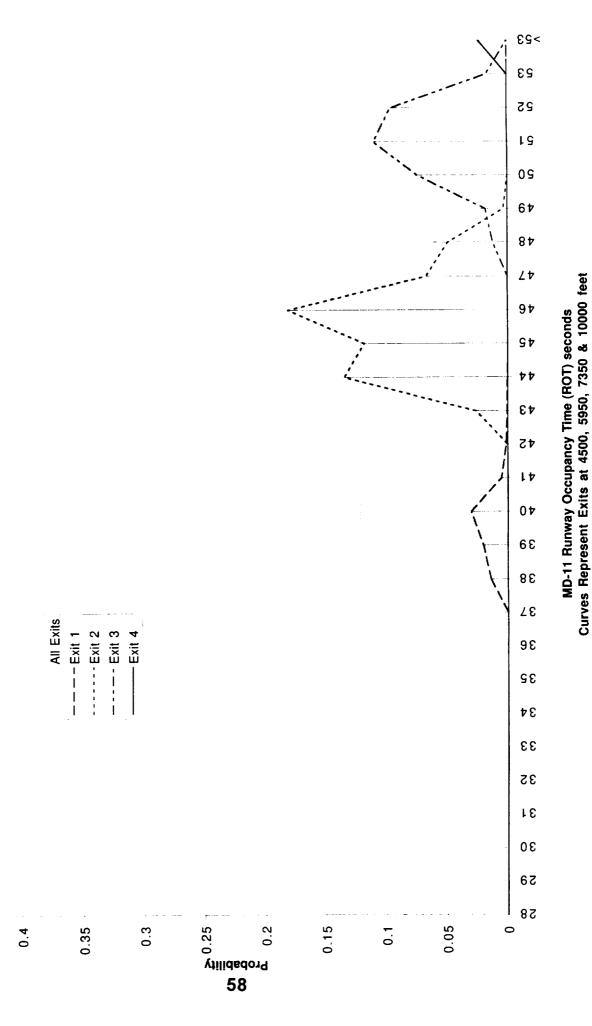


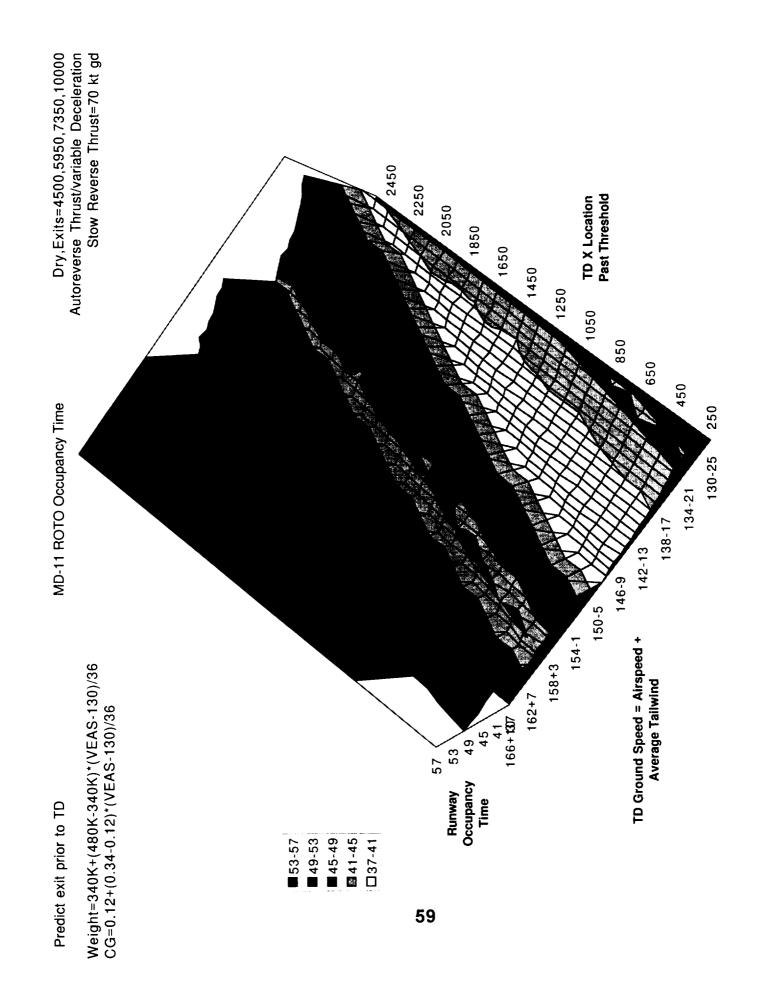
>23 23 25 19 09 6*†* 81 Curves Represent Exits at 3900, 5350, 6950 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds Wet, Auto reverse thrust/variable decel Mean=41.1, STDEV=3.965 43 45 01 38 38 36 32 All Exits - Exit 4 ---Exit 1 ----- Exit 2 ---- Exit 3 **₽**€ 33 35 18 30 58 82 99 Probability 0.25 0.45 0.3 0.15 0.05 4.0 0.35 0.1 0

MD-81 ROTO ROT Probability Distribution

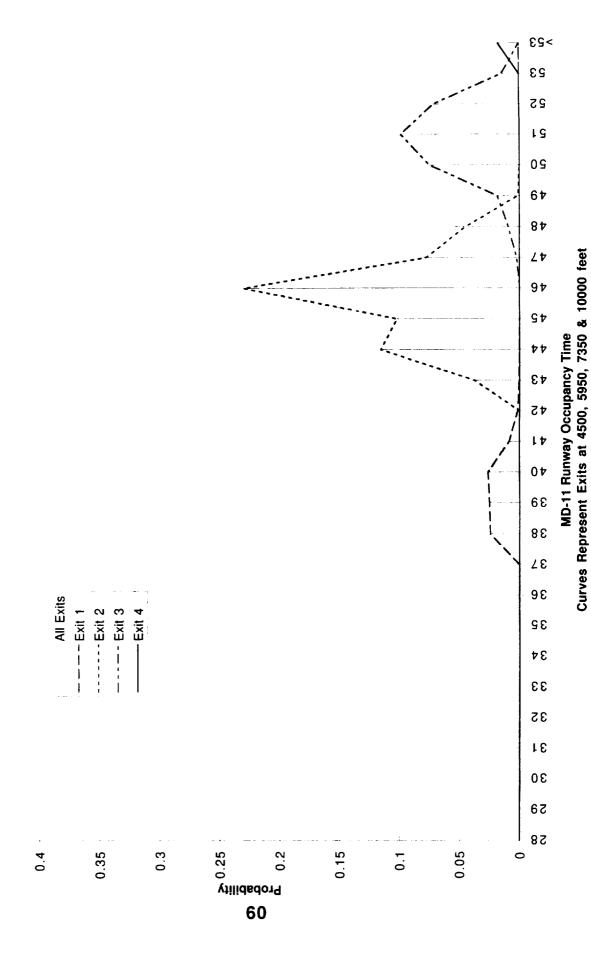


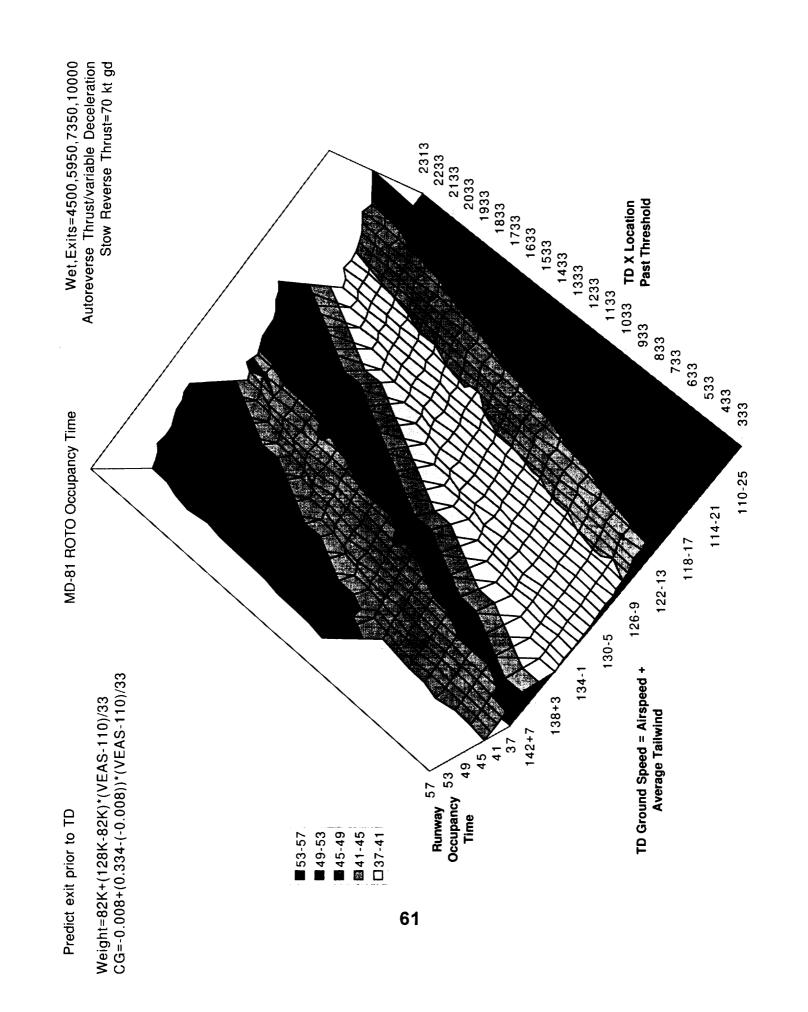
MD-11 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel Mean=47.2, STDEV=4.16





MD-11 ROTO ROT Probability Distribution Dry, Auto reverse thrust/variable decel Mean=46.8, STDEV=4.017

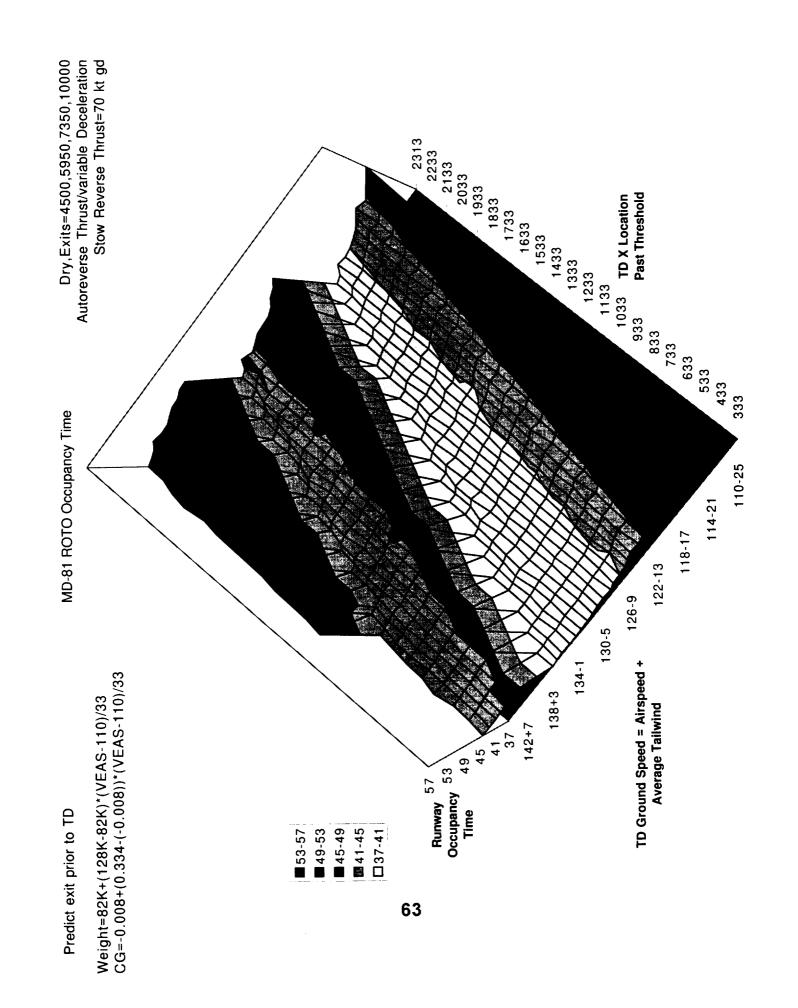




>23 53 25 19 09 6 t 81 **L** 7 91 97 MD-81 Runway Occupancy Time (ROT) seconds Wet, Auto reverse thrust/variable decel Mean=41.2, STDEV=3.219 **t t** £ 7 42 1 7 01 6ε 38 3 2 98 32 All Exits -- Exit 3 - Exit 4 34 ----- Exit 2 ----Exit 1 33 35 18 30 58 82 62 Villidadora 0.05 0.35 0.3 0.15 0.1 0 0.45 0.4

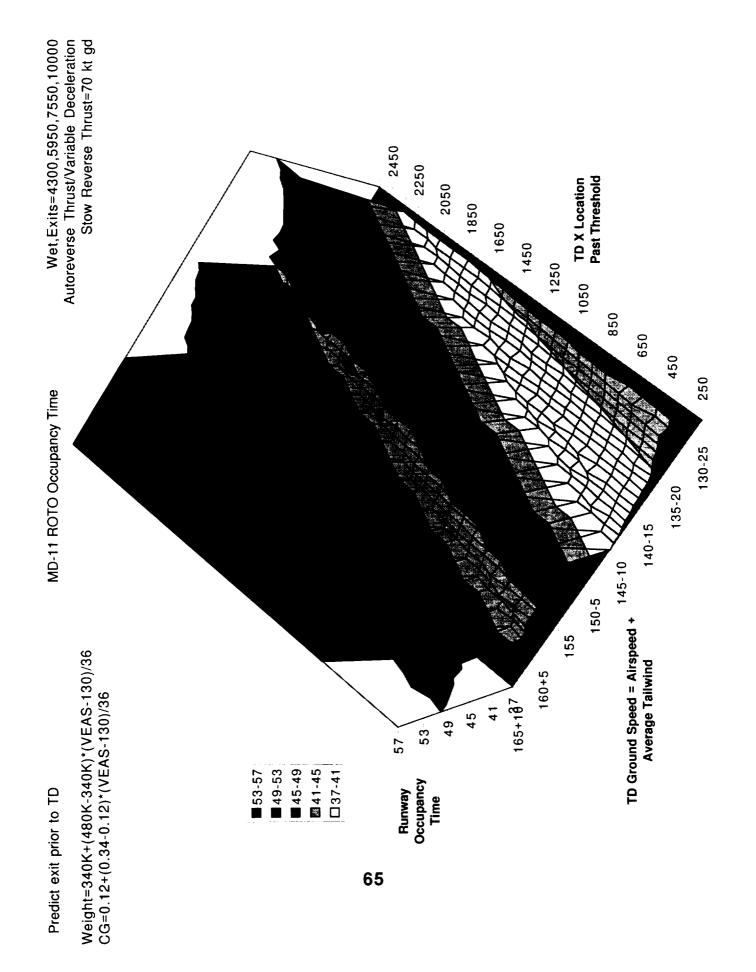
MD-81 ROTO ROT Probability Distribution

Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

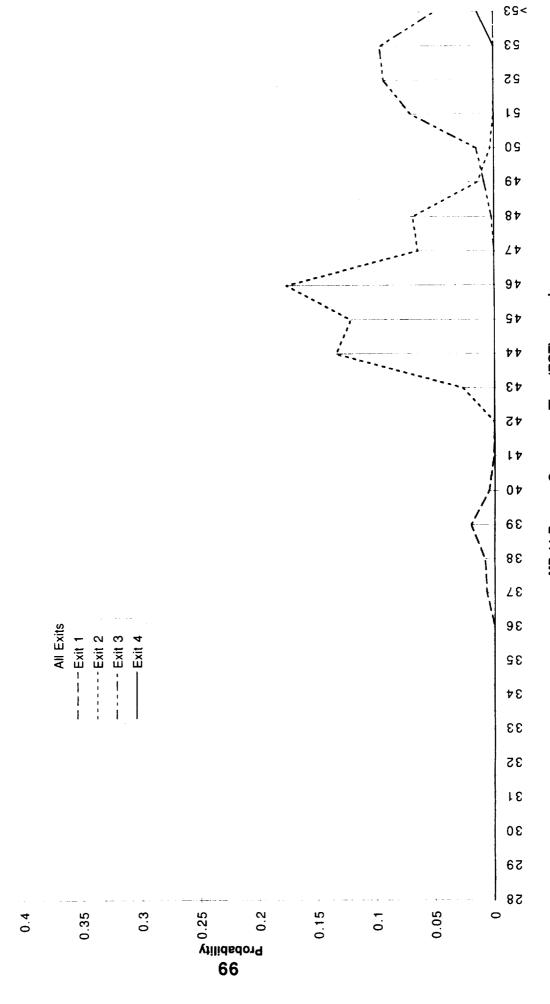


>23 23 25 19 09 6*†* 81 L 7 91 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds Dry, Auto reverse thrust/variable decel Mean=41.2, STDEV=3.219 £ \$ 45 17 0 **t** 38 88 32 98 32 34 All Exits -- Exit 3 ----- Exit 2 - Exit 4 ---Exit 1 33 35 15 30 58 82 64 Villidedora 0.4 0.45 0.3 0.35 0.15 0.05 0.1 0

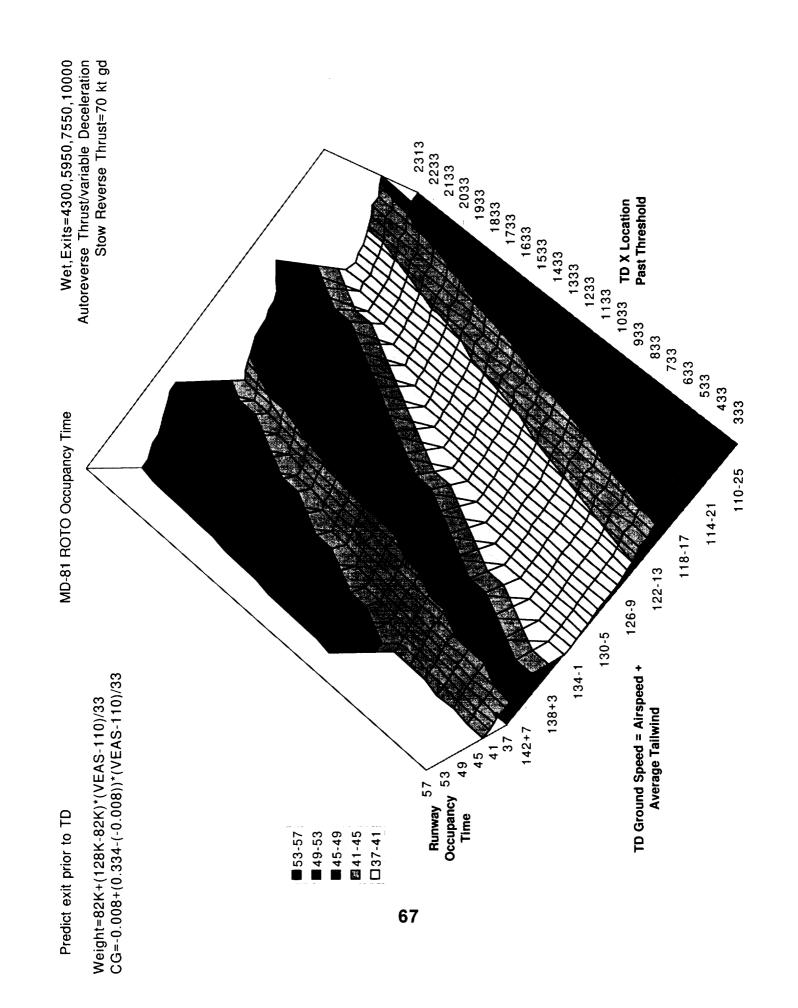
MD-81 ROTO ROT Probability Distribution



MD-11 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel Mean=47.7, STDEV=4.13

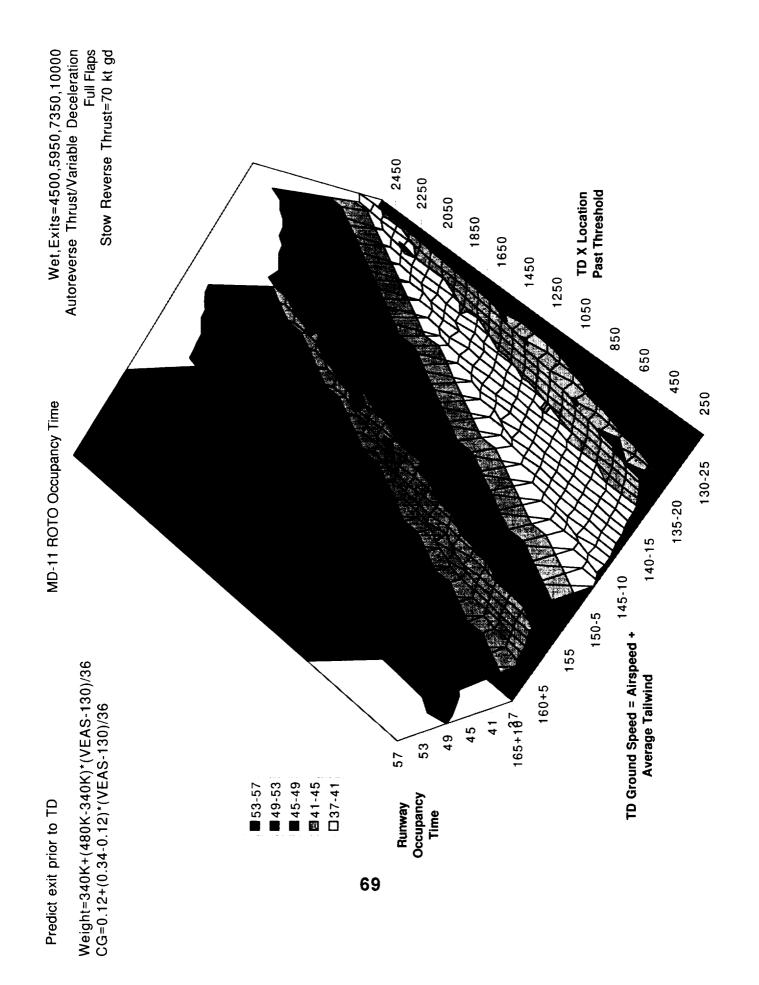


MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4300, 5950, 7550 & 10000 feet

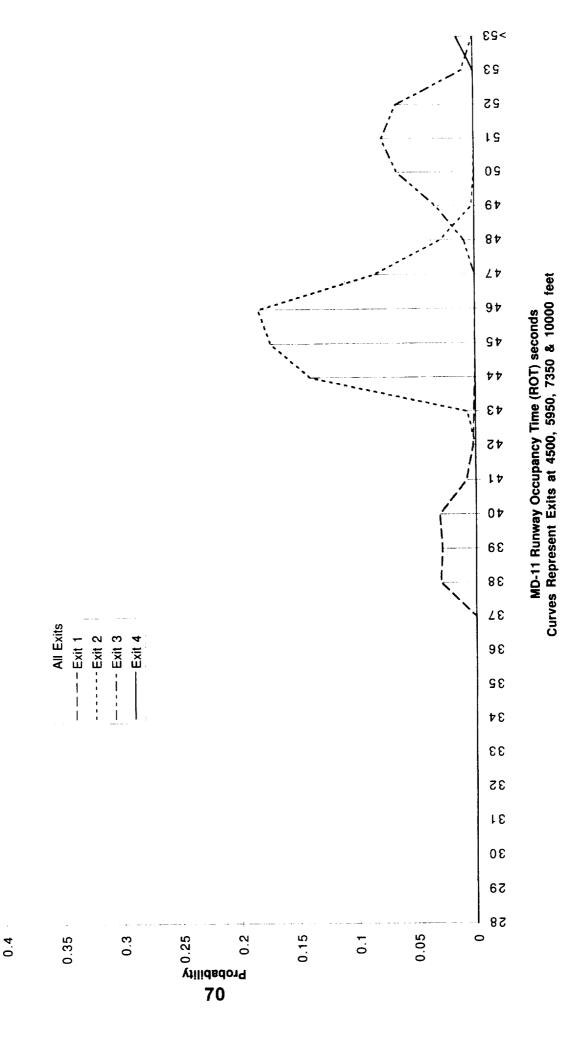


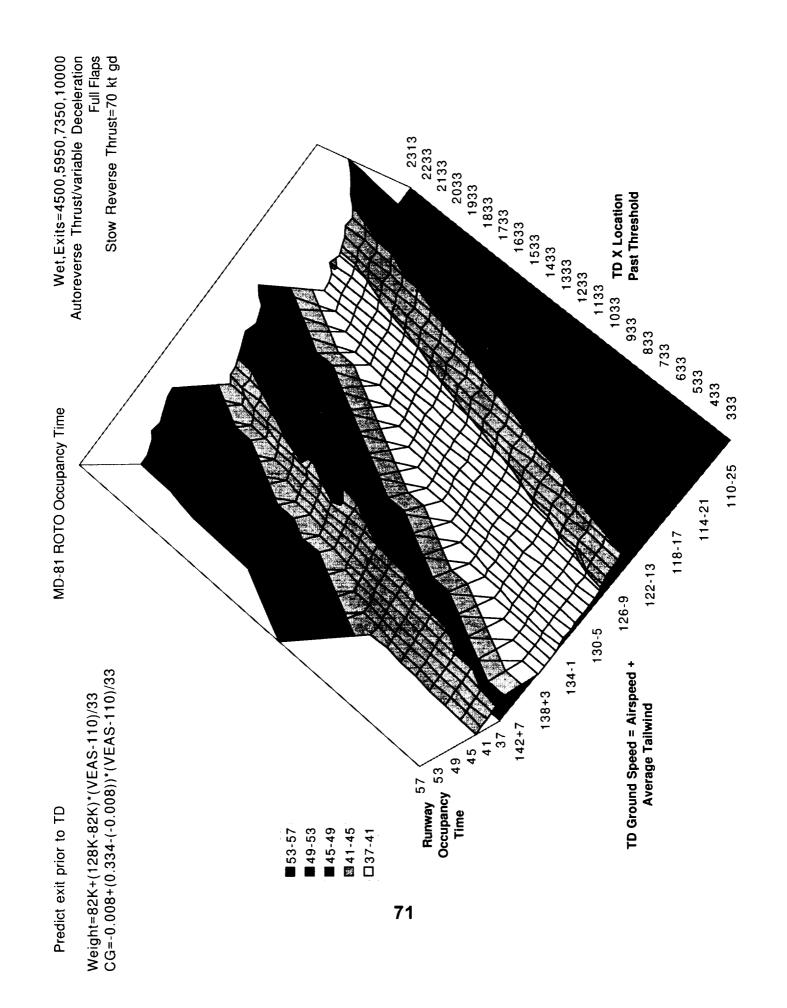
>23 23 25 19 09 6 t All Exits 81 - Exit 3 ----- Exit 2 Exit 4 ----Exit 1 L 7 91 Curves Represent Exits at 4300, 5950, 7550 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds £ \$ 45 17 0 Þ 6ε 88 32 98 32 **7** ¢ εε 35 18 30 58 82 89 Probability 0.25 0.15 0.05 0.35 0.3 0.2 0.4 0.1 0

MD-81 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel Mean=41.5, STDEV=4.161

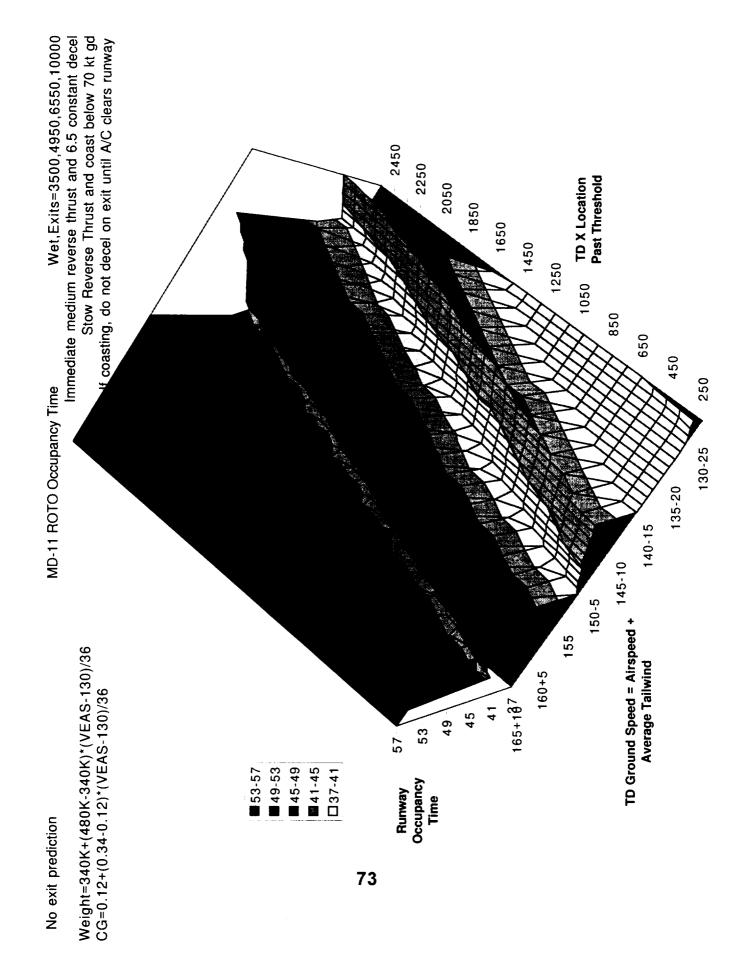


MD-11 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel/full flaps Mean=46.4, STDEV=3.9

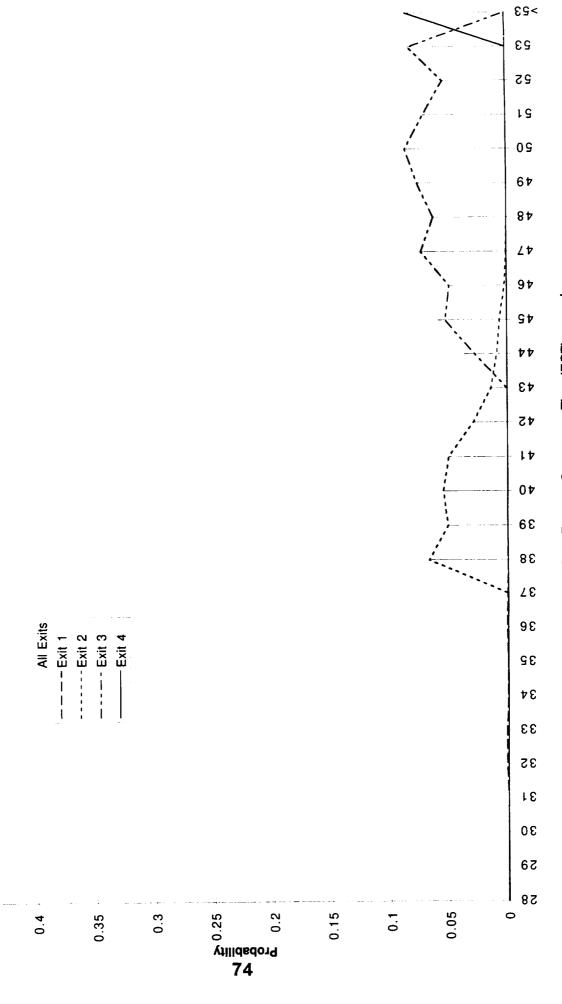




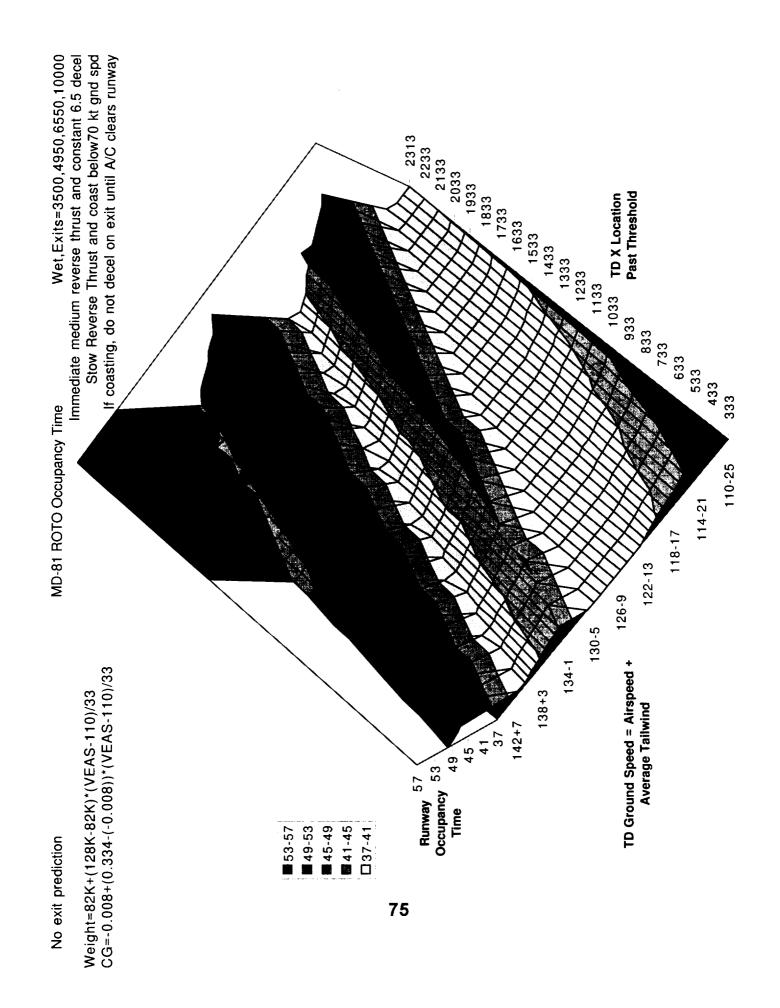
>23 23 25 19 09 6*†* 81 ۷ ۶ Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 91 MD-81 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel/full flaps Mean=41.2, STDEV=3.505 MD-81 Runway Occupancy Time (ROT) seconds **t**3 45 0 Þ 39 38 ٤٤ 9 E All Exits 32 - Exit 3 Exit 4 ----- Exit 2 --Exit 1 **7** ¢ 33 35 18 30 58 82 72 Villidsdorq 0.05 0.15 0 0.45 0.35 0.3 0.1 0.4



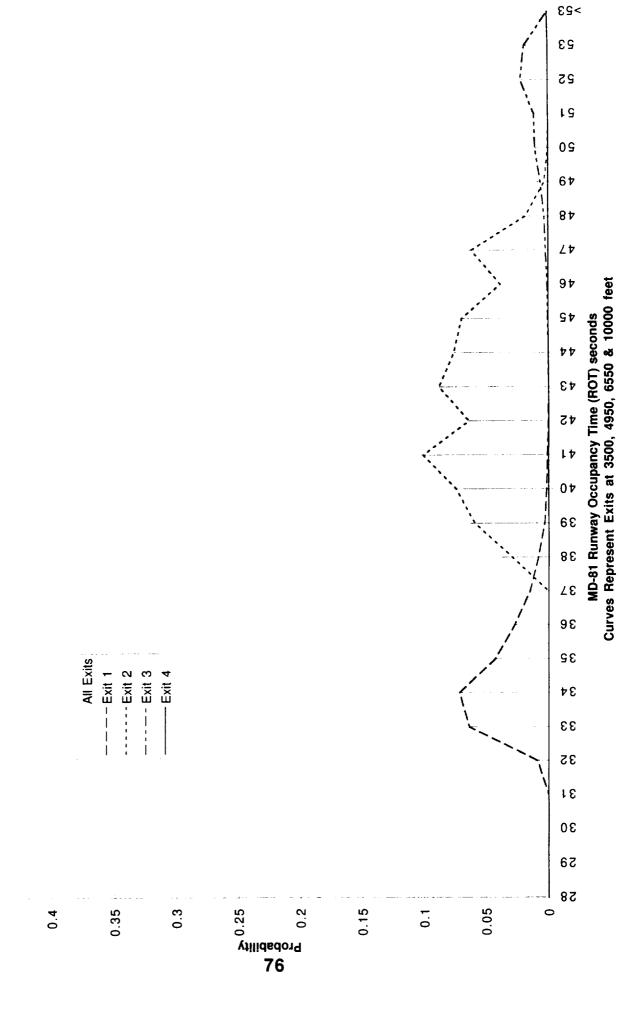
MD-11 ROTO ROT Probability Distribution Wet, Medium reverse thrust/constant 6.5 decel Mean=48.5, STDEV=9.01

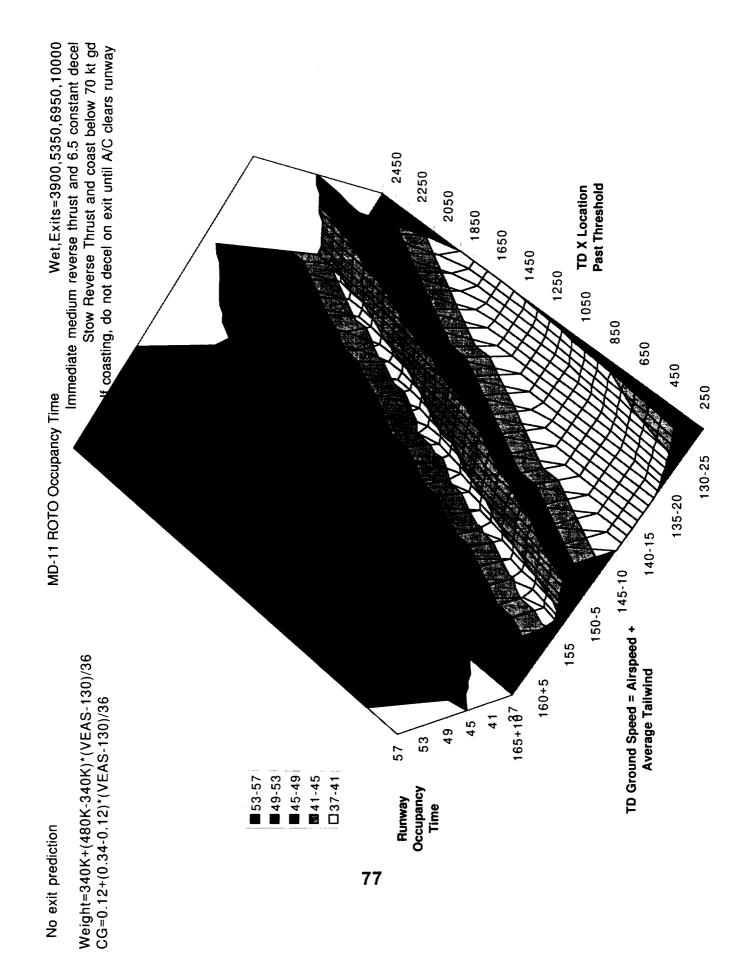


MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3500, 4950, 6550 & 10000 feet

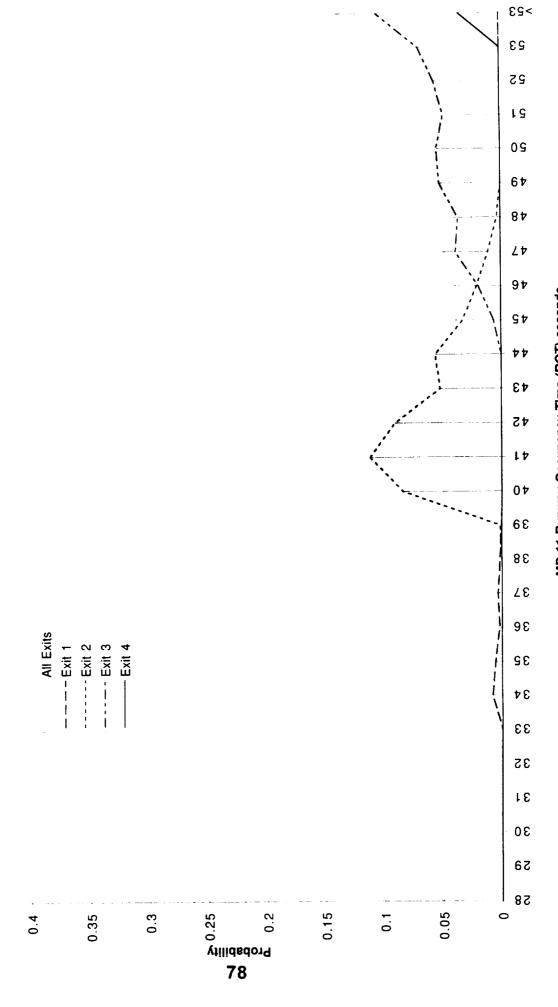


MD-81 ROTO ROT Probability Distribution Wet, Medium reverse thrust/constant 6.5 decel Mean=41.3, STDEV=5.099

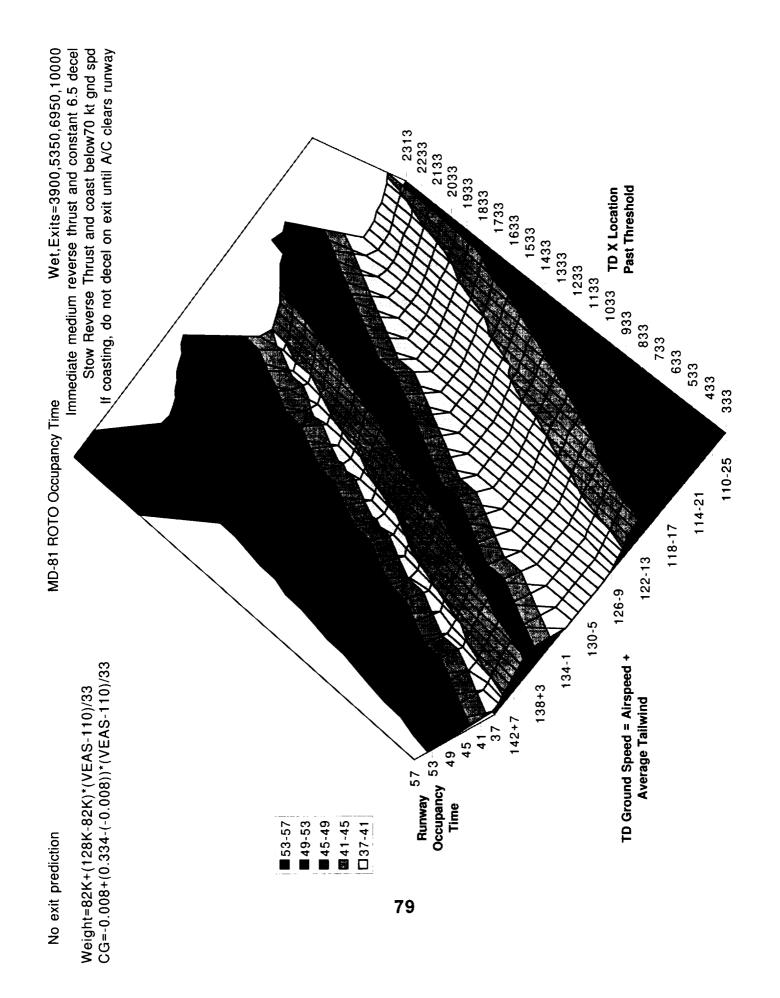




MD-11 ROTO ROT Probability Distribution Wet, Medium reverse thrust/constant 6.5 decel Mean=51.2, STDEV=6.63



MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3900, 5350, 6950 & 10000 feet



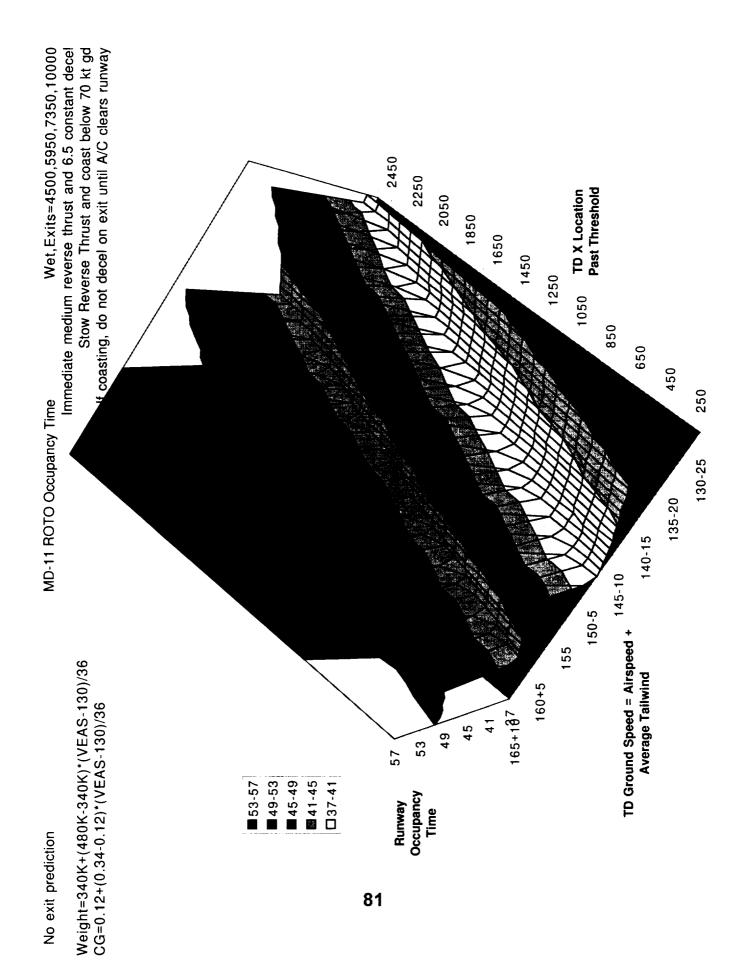
23 25 All Exits .- Exit 3 Exit 4 ----- Exit 2 ----Exit 1 19 09 61 81 **۷** Curves Represent Exits at 3900, 5350, 6950 & 10000 feet 91 94 MD-81 Runway Occupancy Time (ROT) seconds _マ £ \$ 45 17 01 38 8 E 37 98 32 **34** 33 35 18 30 58 82 08 Probability 0.05 0.15 0.35 0.3 0.4 0.1 0

Wet, Medium reverse thrust/constant 6.5 decel Mean=41.3, STDEV=4.894

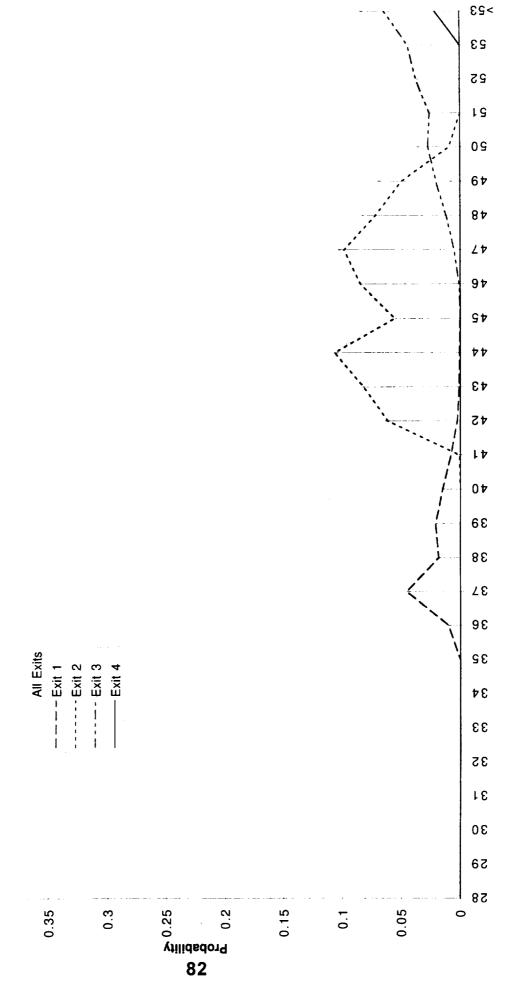
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MD-81 ROTO ROT Probability Distribution

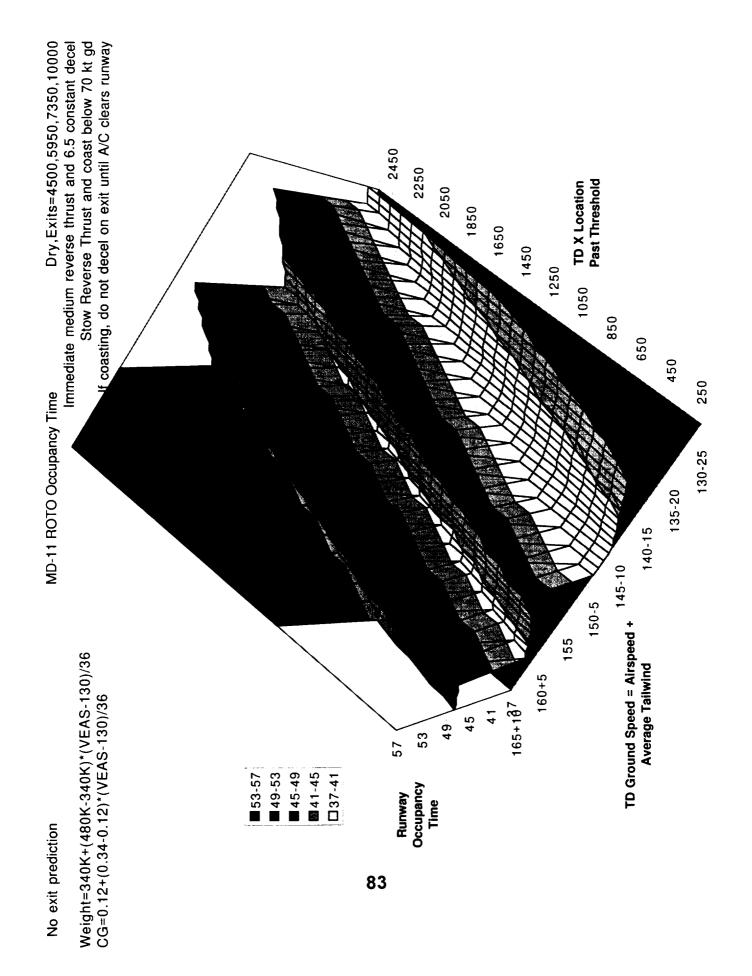
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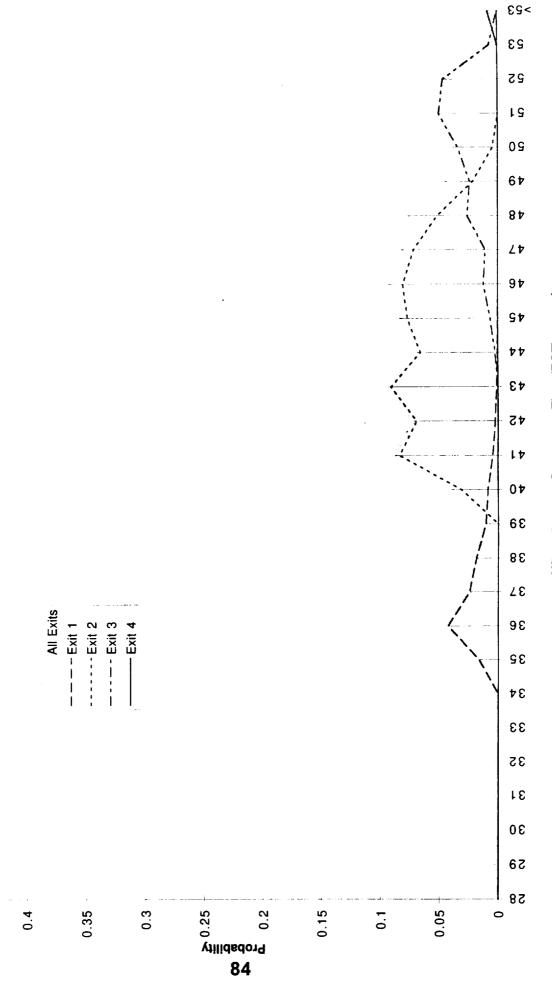
MD-11 ROTO ROT Probability Distribution Wet, Medium reverse thrust/constant 6.5 decel Mean=46.6, STDEV=6.12



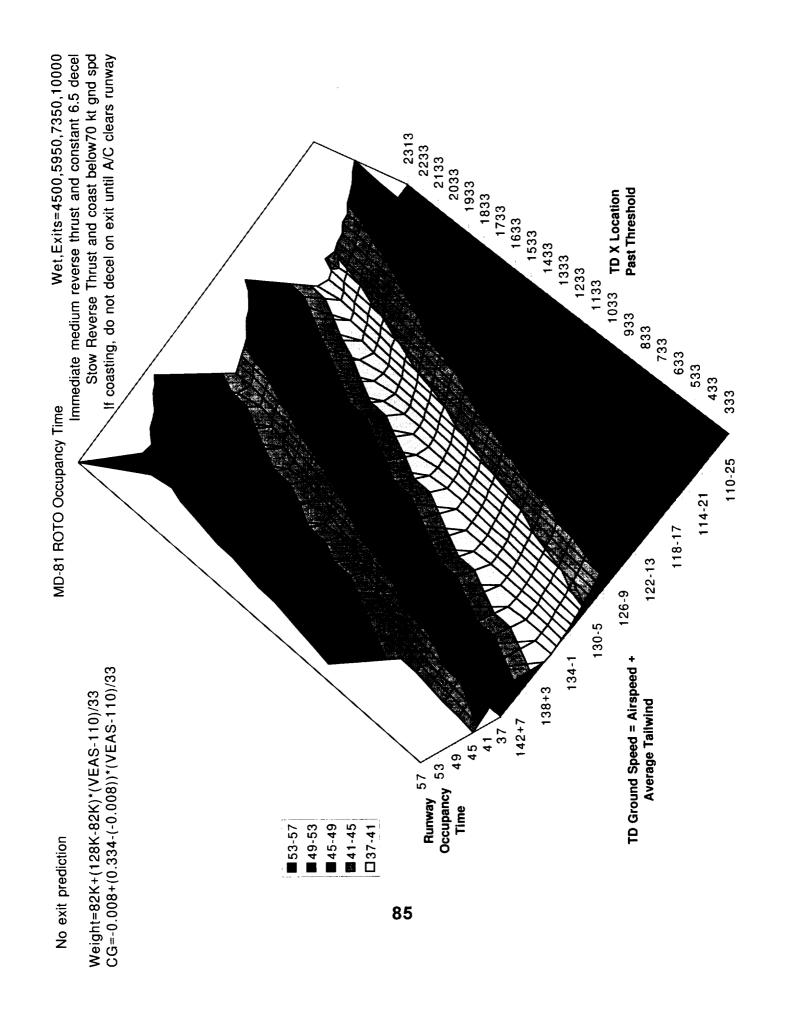
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



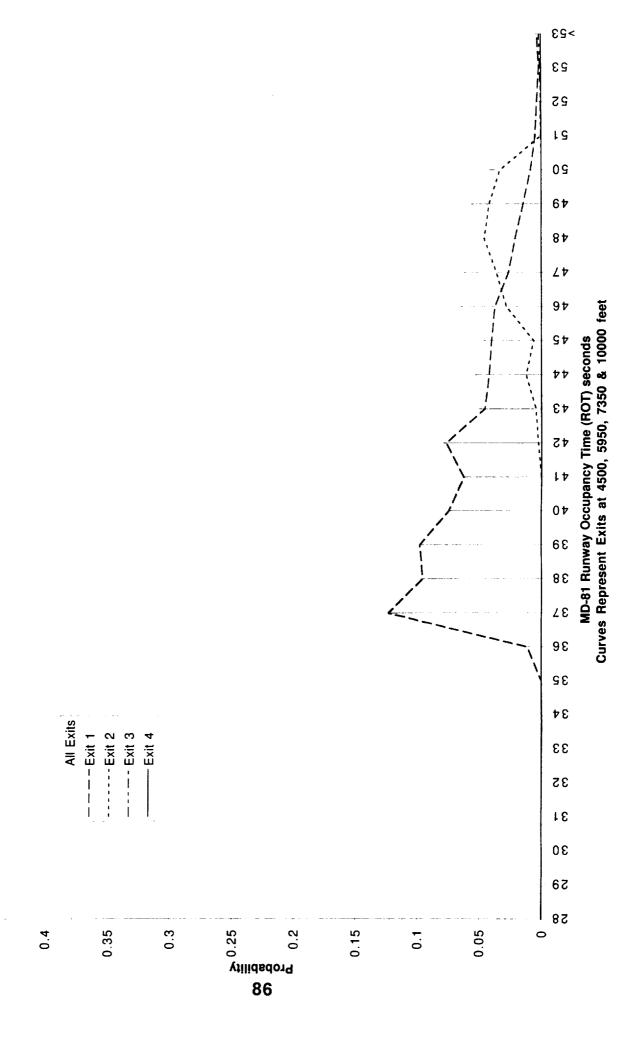
MD-11 ROTO ROT Probability Distribution Dry, Medium reverse thrust/constant 6.5 decel Mean=44.7, STDEV=4.74

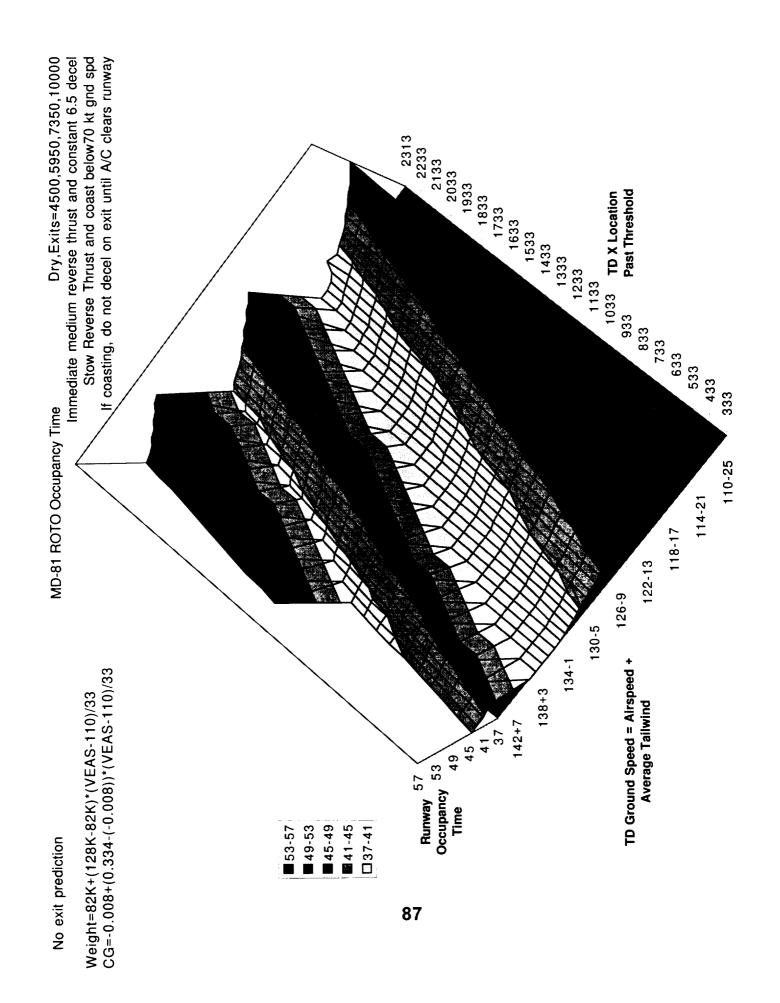


MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

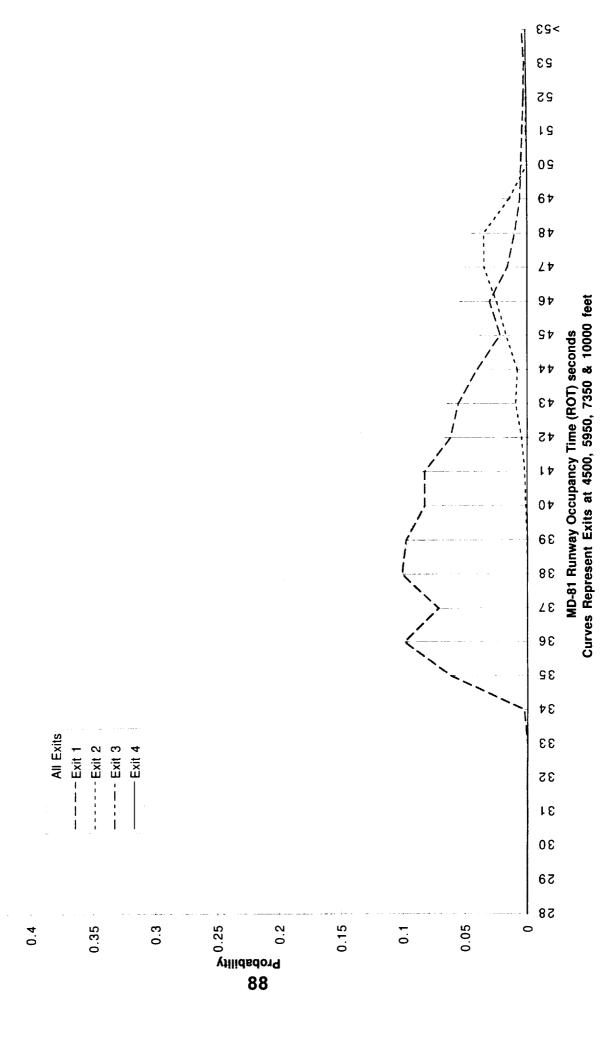


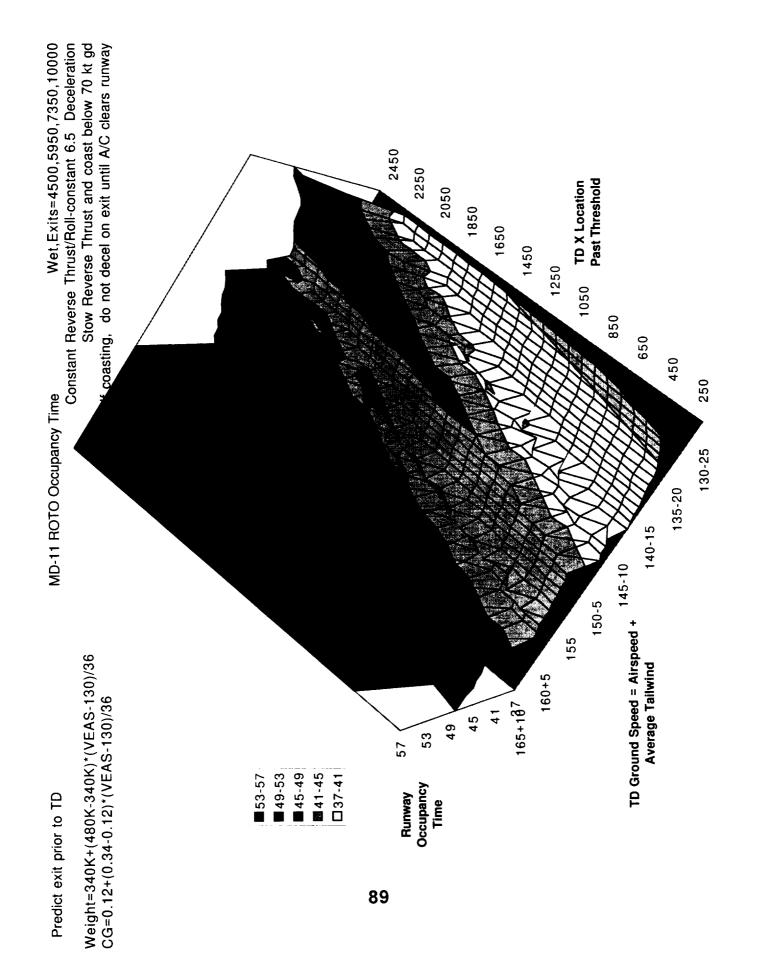
MD-81 ROTO ROT Probability Distribution Wet, Medium reverse thrust/constant 6.5 decel Mean=42.5, STDEV=4.34





MD-81 ROTO ROT Probability Distribution Dry, Medium reverse thrust/constant 6.5 decel Mean=40.9, STDEV=4.161

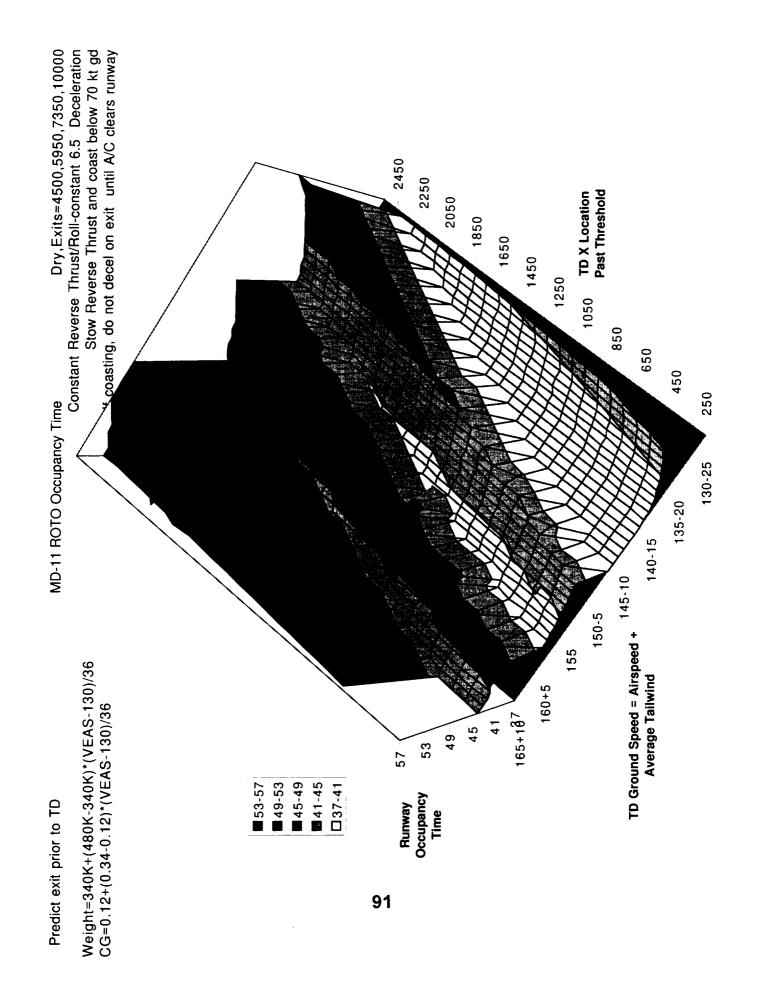




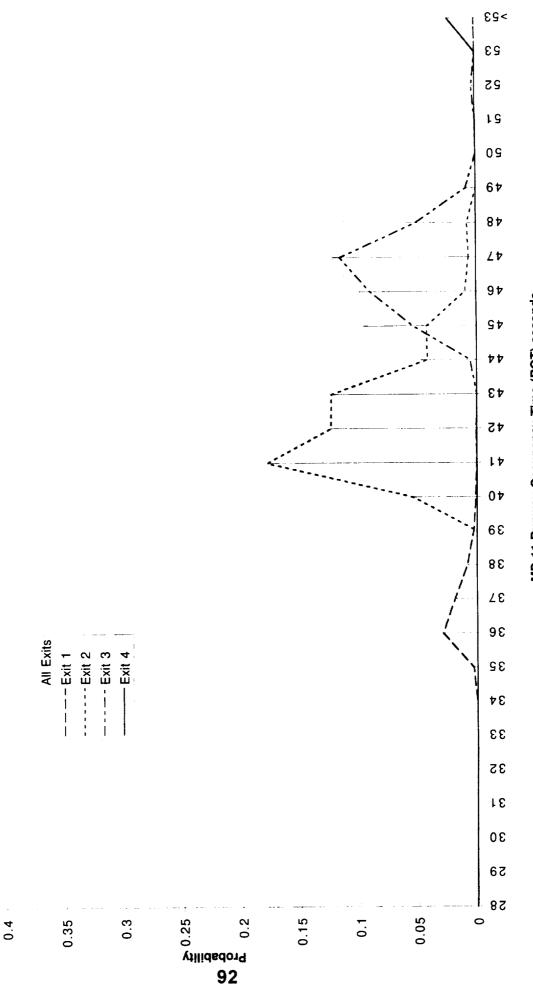
23 25 19 09 6*†* 84 ۷ ا Wet, Constant reverse thrust/roll-constant 6.5 decel Mean=45.7, STDEV=3.73 9 t 97 MD-11 ROTO ROT Probability Distribution _マ **t**3 **₹**5 17 0 t 38 88 ٤٤ 98 32 All Exits - Exit 3 ----- Exit 2 Exit 4 -- Exit 1 34 33 35 18 30 58 82 **06** Probability 0.25 0.35 0.45 0.3 0.15 0.05 0.4 0.1 0

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

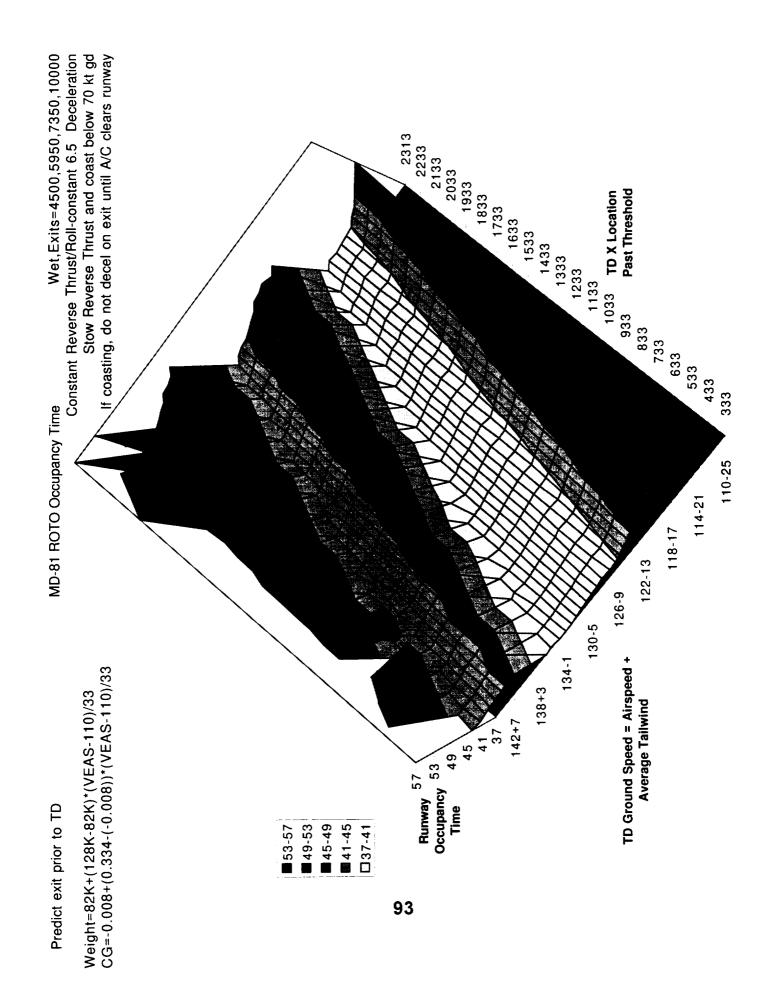
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MD-11 ROTO ROT Probability Distribution Dry, Constant reverse thrust/roll-constant 6.5 decel Mean=43.6, STDEV=3.62



MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

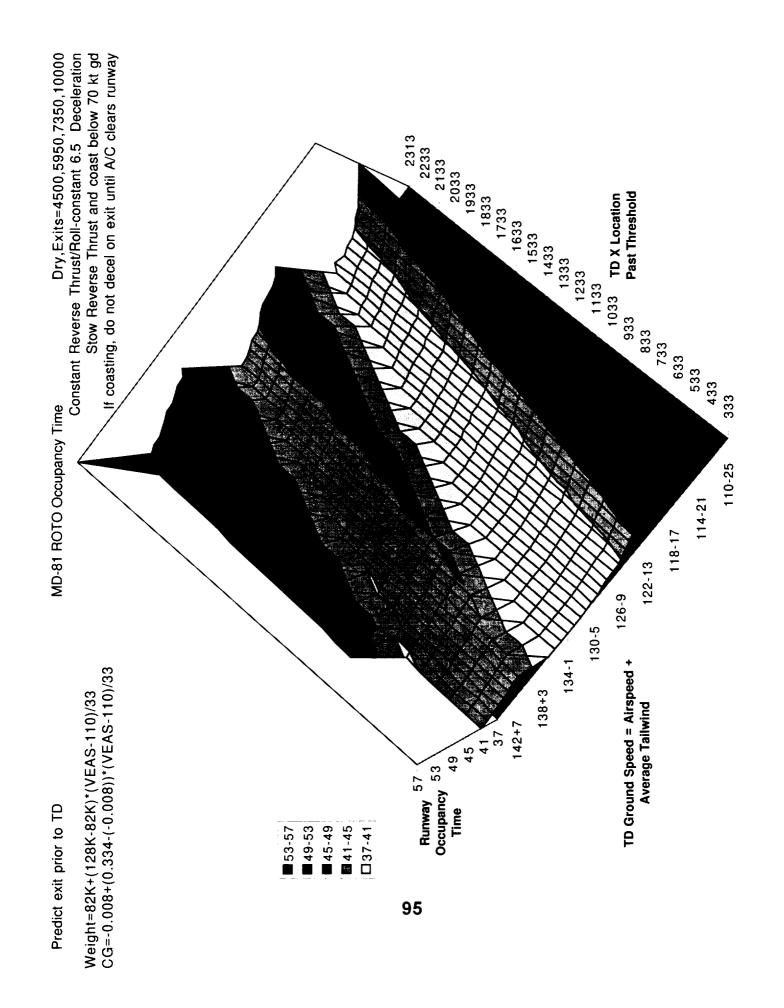


>23 23 25 19 09 6*†* 84 ۷7 91 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds 843 77 0*t* 38 38 98 32 All Exits - Exit 4 ----- Exit 2 ---- Exit 3 ---Exit 1 34 $\epsilon\epsilon$ 35 15 30 58 82 0.05 94 Villidedorq 0.4 0.35 0.3 0.15 0.1 0

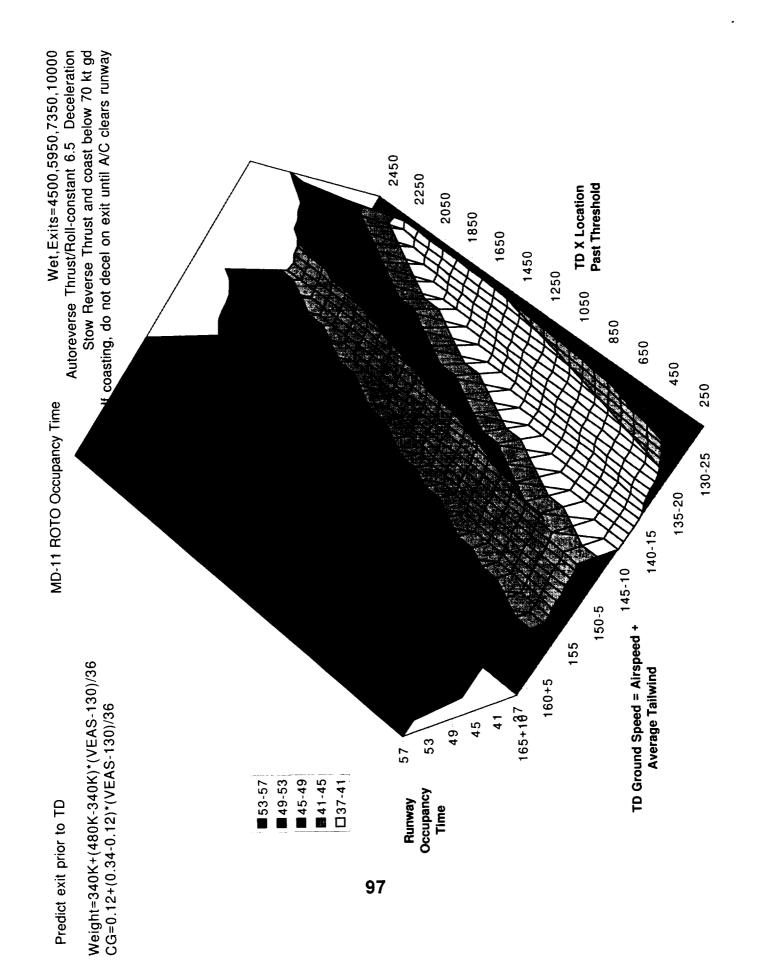
Wet, Constant reverse thrust/roll-constant 6.5 decel

Mean=41.7, STDEV=3.731

0.45

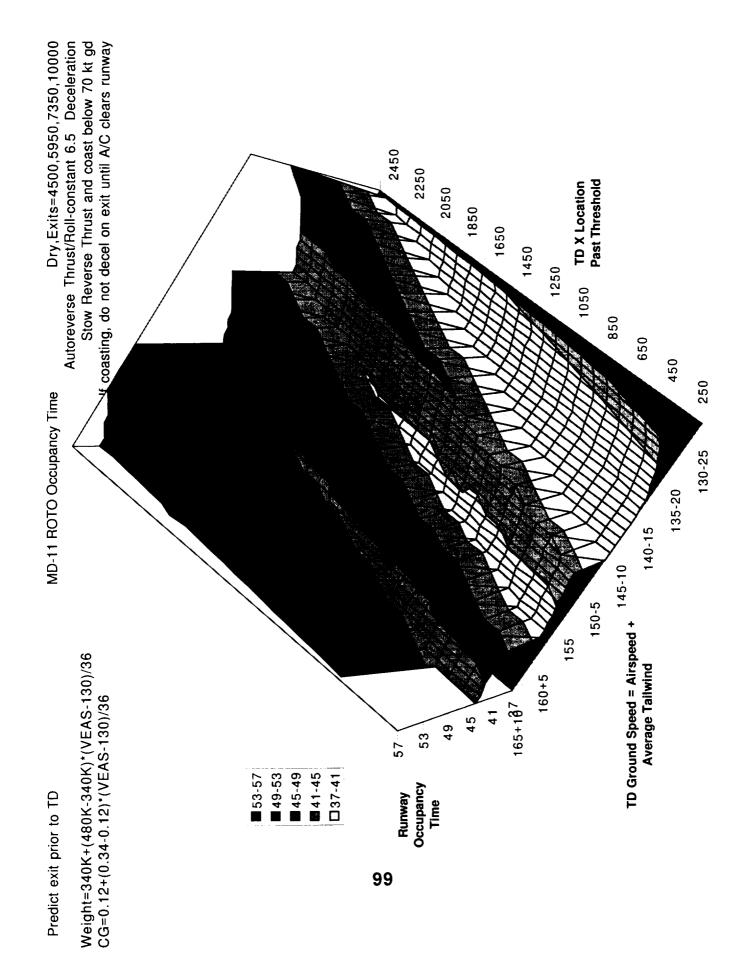


>23 23 25 13 09 6 Þ 81 91 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet Dry, Constant reverse thrust/roll-constant 6.5 decel Mean=40.8, STDEV=3.688 97 MD-81 Runway Occupancy Time (ROT) seconds E 7 45 0 7 39 38 ٤٤ 98 32 34 All Exits - Exit 1 ----- Exit 3 ----- Exit 2 33 35 34 30 58 82 Villidsdor9 0.05 0.45 0.35 0.3 0.2 0.15 0.1 0 0.4 96



>23 23 25 19 09 6 t 84 L Þ 91 Wet, Auto reverse thrust/roll-constant 6.5 decel Mean=47.1, STDEV=5.27 97 t t £ 7 45 17 0 Þ 38 38 ٤٤ 98 32 All Exits - Exit 3 ----- Exit 2 Exit 4 ----Exit 1 34 33 35 34 30 58 82 86 Willidadora O 55 S 55 0.45 0.4 0.35 0.3 0.15 0.05 0.1 0

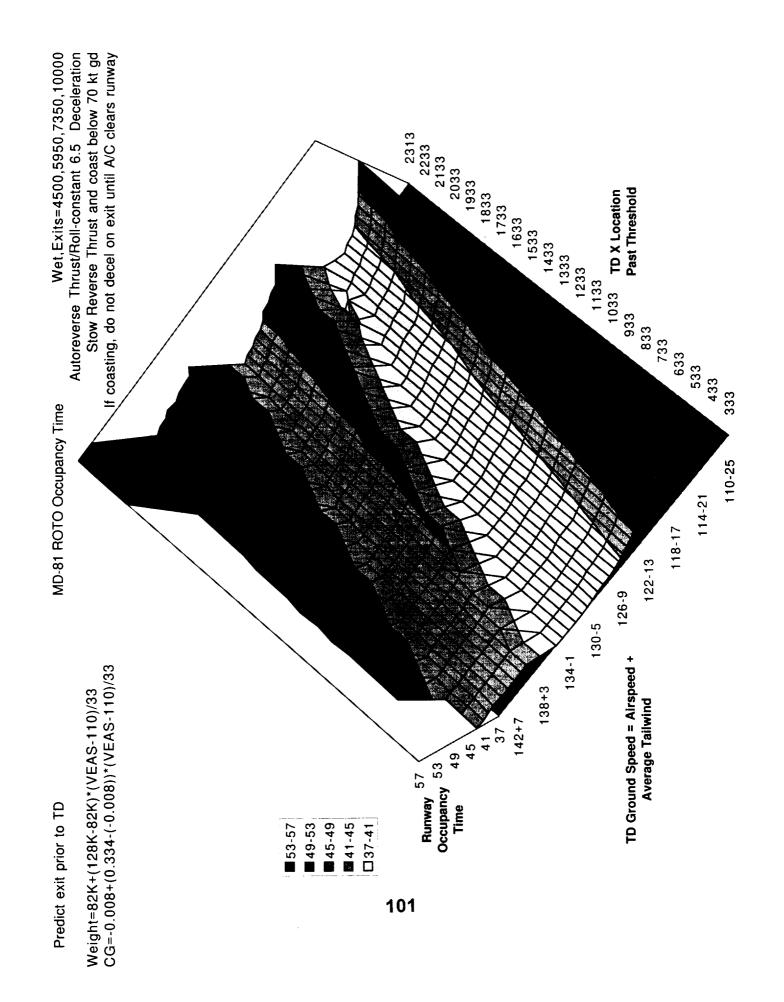
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



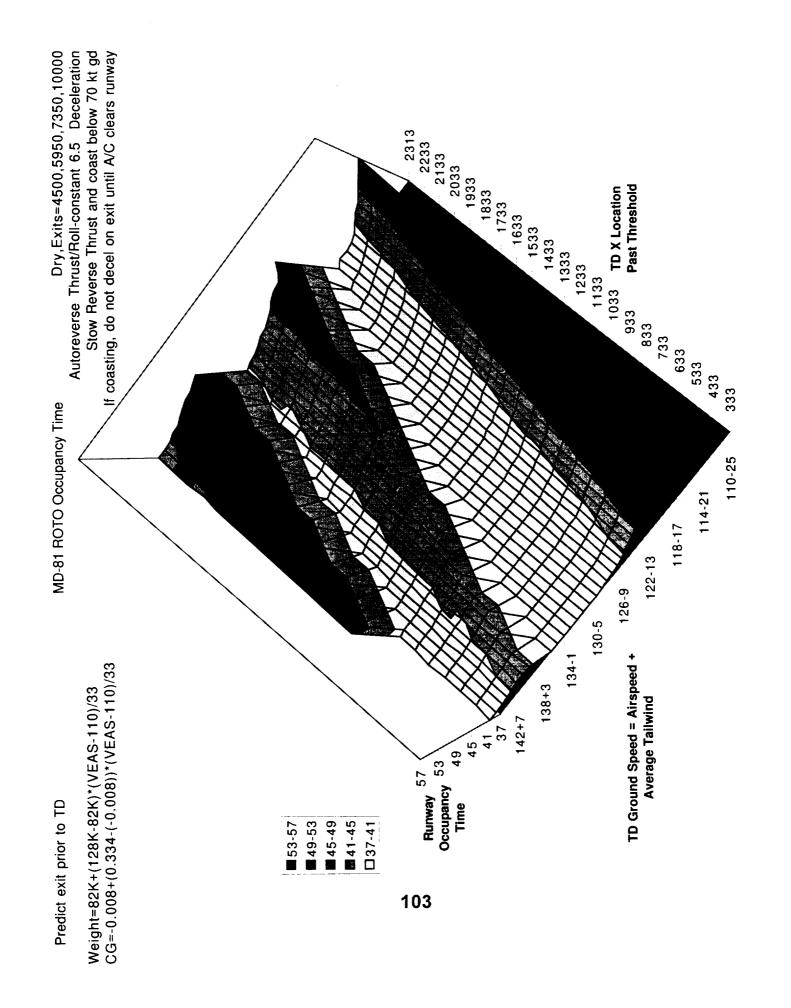
23 25 19 09 6*t* 8 Þ **۷** 91 Dry, Auto reverse thrust/roll-constant 6.5 decel Mean=43.8, STDEV=3.65 97 MD-11 ROTO ROT Probability Distribution t t £ \$ 45 17 01 38 38 ٤٤ 98 32 All Exits ----Exit 1 ----- Exit 2 —- Exit 3 - Exit 4 **⊅**€ 33 35 18 30 58 82 000 Probability 0.35 0.3 0.15 0.05 0.45 0.4 0.1 0

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

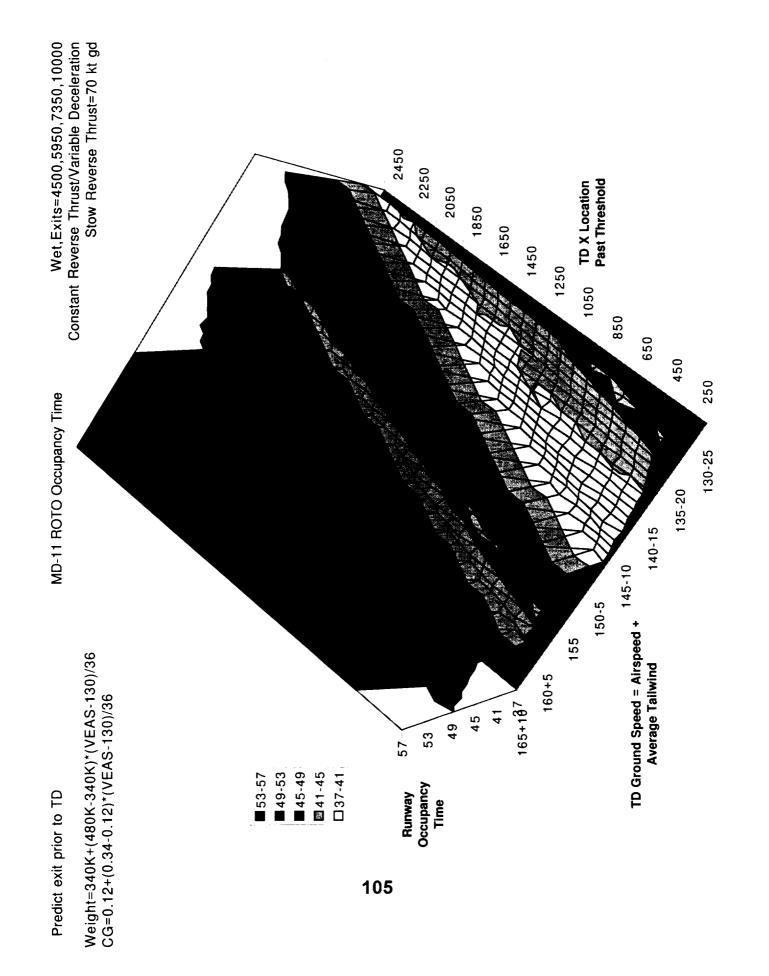
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>23 23 25 13 90 61 81 47 91 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet Wet, Auto reverse thrust/roll-constant 6.5 decel Mean=40.8, STDEV=3.57 94 MD-81 Runway Occupancy Time (ROT) seconds t t £ Þ 45 17 0 Þ 36 88 ٤٤ 98 32 34 All Exits Exit 4 ----Exit 1 ----- Exit 2 ----- Exit 3 33 35 15 30 58 82 102 Villidedora S. S. 0.45 0.3 0.15 0.1 0.05 0.4 0.35 0



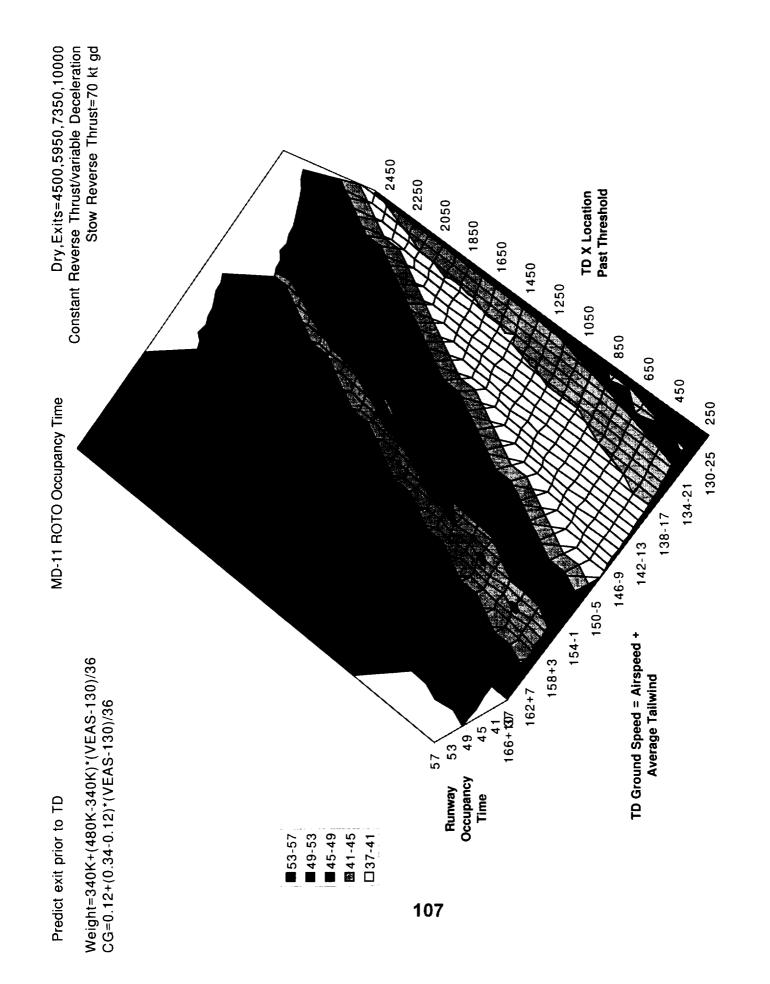
>23 23 25 19 09 6Þ 81 L Þ Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 91 Dry, Auto reverse thrust/roll-constant 6.5 decel 97 MD-81 Runway Occupancy Time (ROT) seconds Mean=39.6, STDEV=3.539 £ \$ 45 0 Þ 6ε 38 ٤٤ 98 32 34 33 All Exits - Exit 4 ----Exit 1 ----- Exit 2 ---- Exit 3 35 18 30 58 82 Villidsdor9 0.05 0.45 0.4 0.35 0.3 0.2 0.15 0.1 0 104



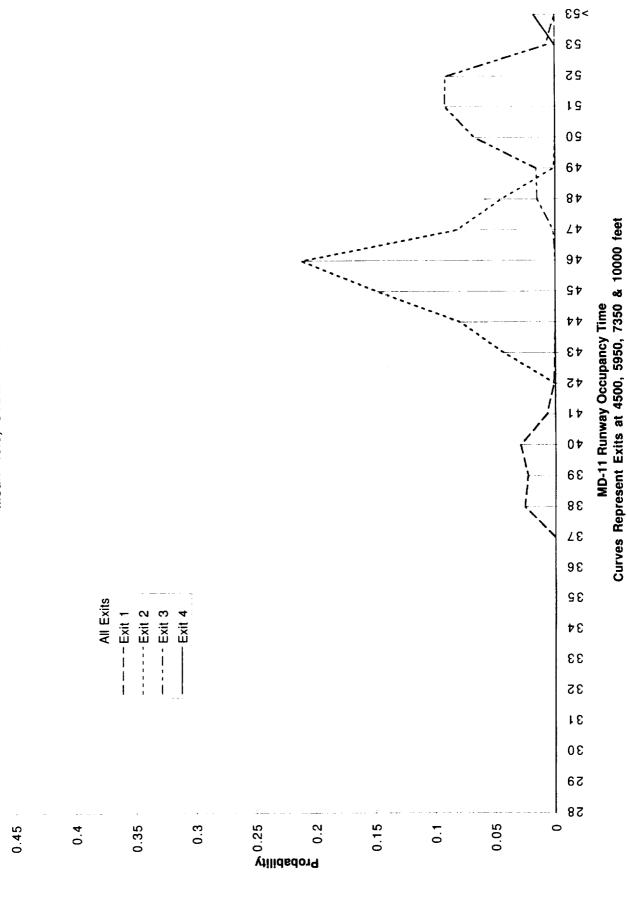
23 25 19 9 6 t 81 **1** t 91 Wet, Constant reverse thrust/variable decel Mean=47.3, STDEV=4.14 97 MD-11 ROTO ROT Probability Distribution t t **t**3 45 17 0⊅ 33 38 37 98 All Exits -- Exit 3 ----- Exit 2 ----Exit 1 32 34 33 35 18 30 58 82 901 Probability 0.35 0.3 0.05 0.15 0.1 0 0.45 0.4

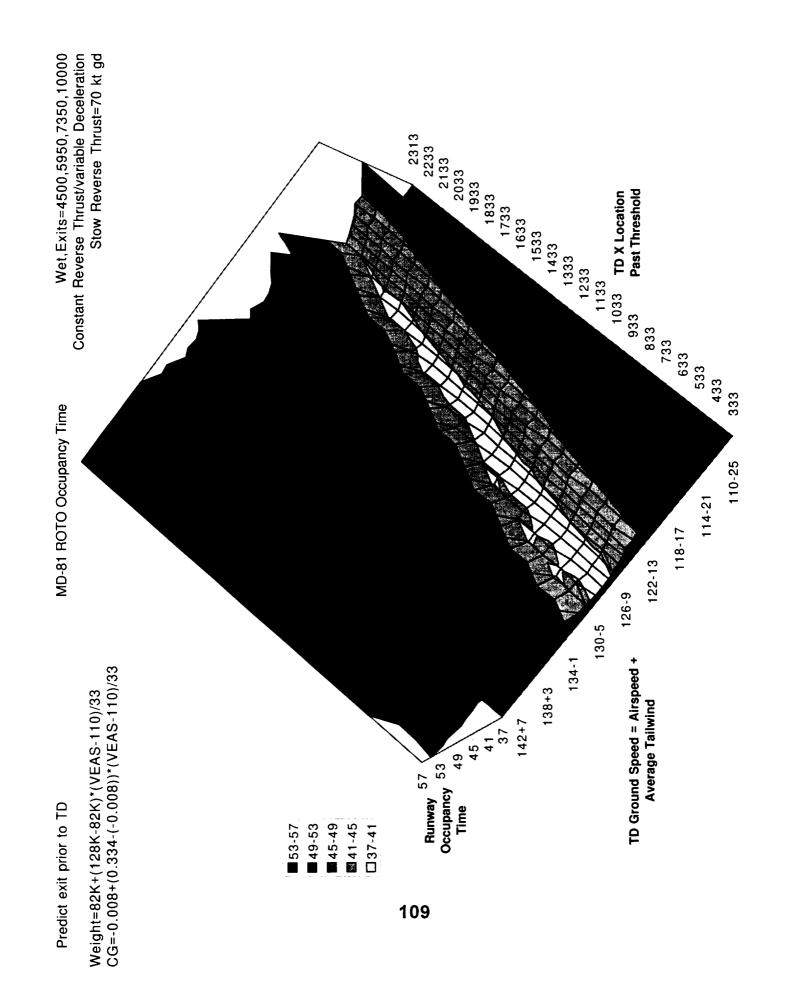
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

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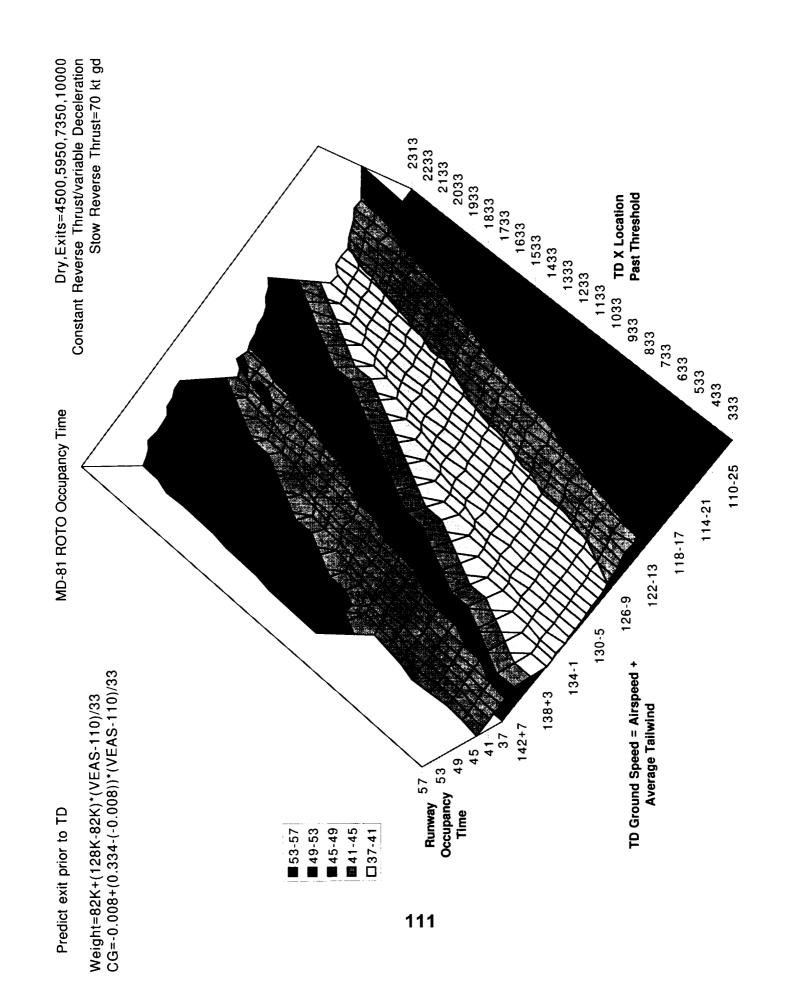
MD-11 ROTO ROT Probability Distribution Dry, Constant reverse thrust/variable decel Mean=46.8, STDEV=4.026



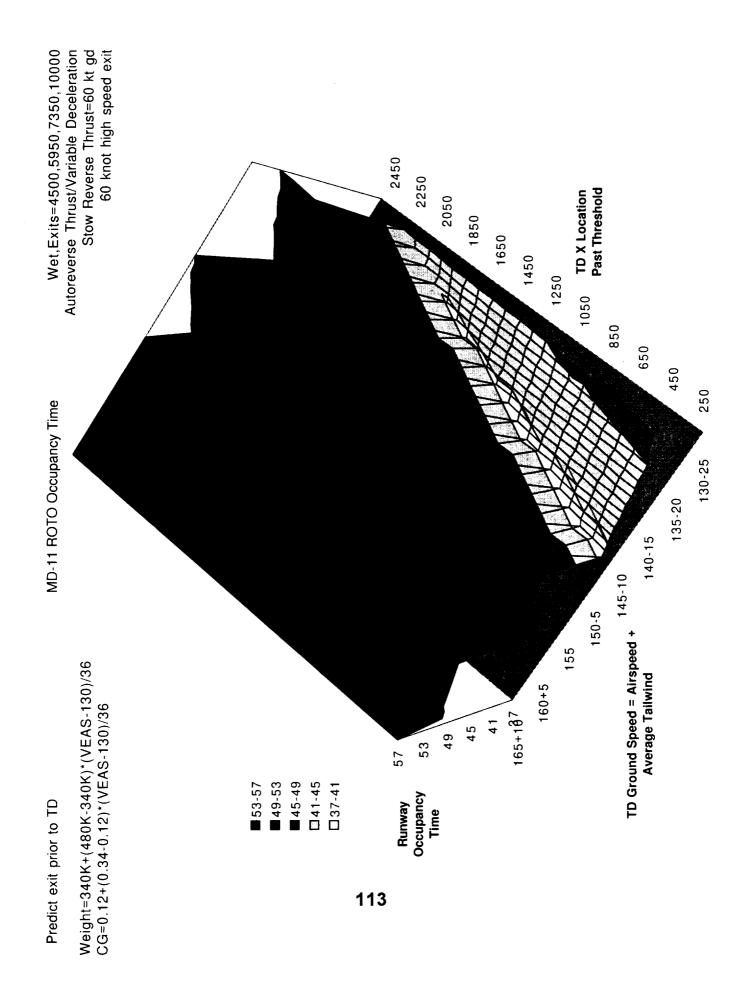


23 25 19 09 6*†* 81 L Þ Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 91 94 MD-81 Runway Occupancy Time (ROT) seconds Wet, Constant reverse thrust/variable decel Mean=46.7, STDEV=4.407 843 45 14 01 38 38 ٤٤ 98 32 All Exits 34 -- Exit 3 ----- Exit 2 ----Exit 1 33 35 18 30 58 82 Villidadory 0.25 0.15 0.05 0.45 4.0 0.35 0.3 0.2 0.1 0 110

>23

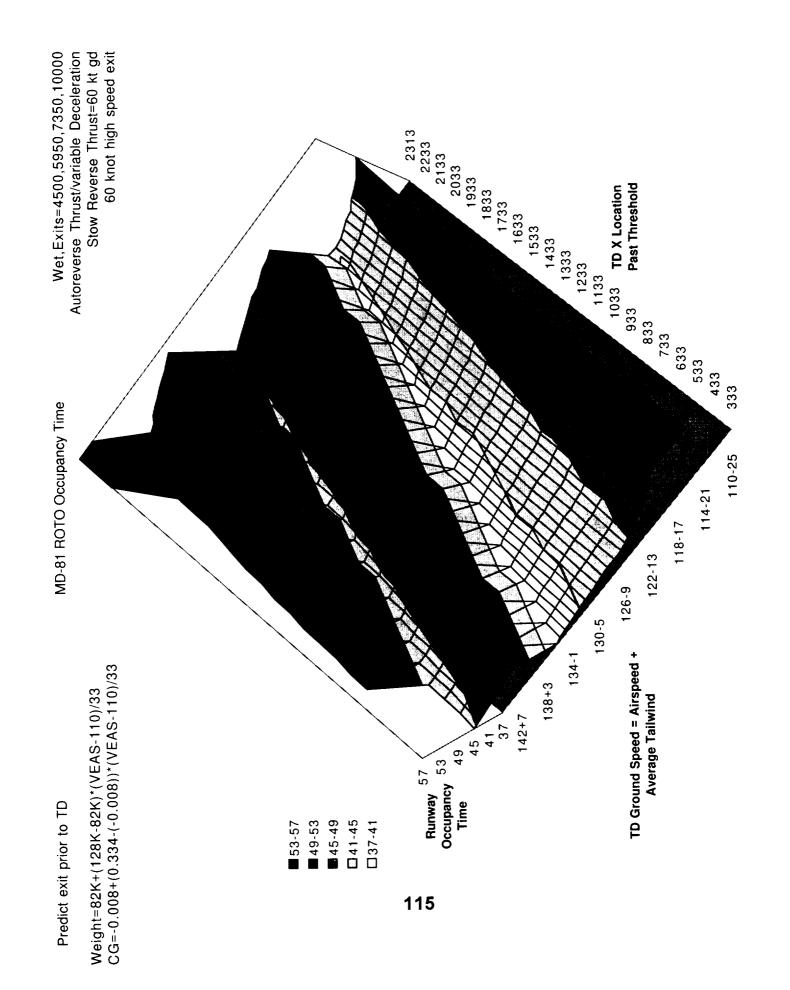


>23 23 25 19 09 6*†* 84 ۷4 91 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds Dry, Constant reverse thrust/variable decel t t Mean=41.2, STDEV=3.217 £ \$ 45 1 7 0 \$ 38 88 3 2 98 32 All Exits 34 ----- Exit 2 ----- Exit 3 ----Exit 1 - Exit 4 33 35 18 30 58 82 Villidador9 0.15 0.05 0.45 4.0 0.35 0.3 0.2 0.1 0 112



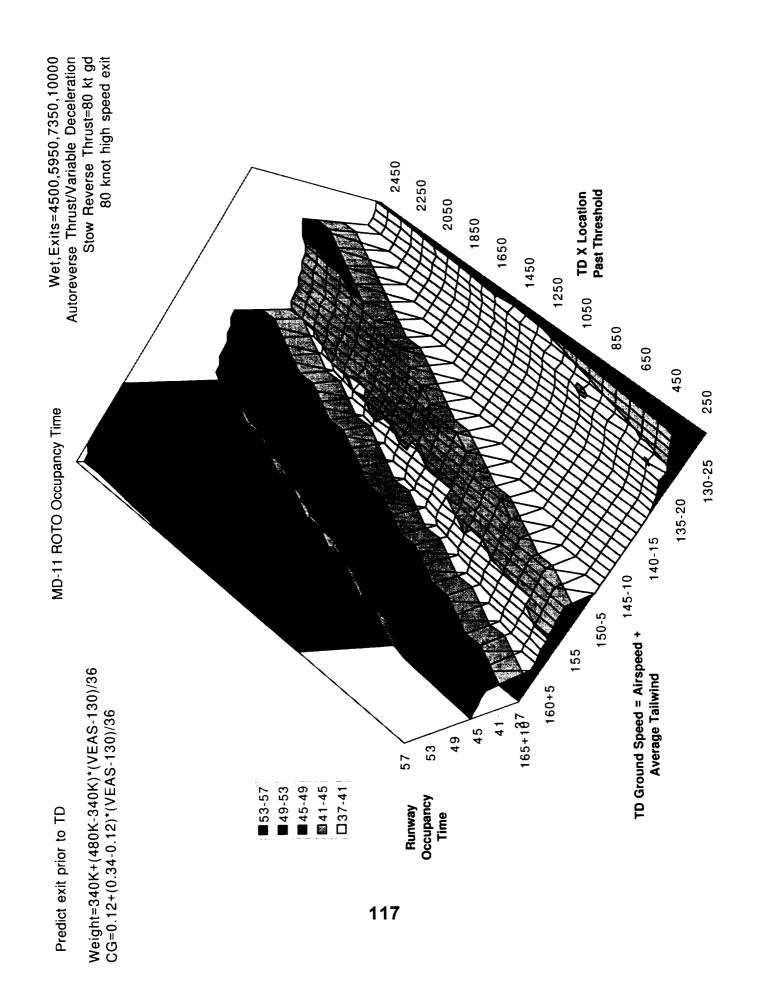
>23 23 25 13 09 61 81 17 Wet, Auto reverse thrust/variable decel/60 kt exit speed Mean=51.6, STDEV=5.19 91 97 **MD-11 ROTO ROT Probability Distribution** t t £ 7 45 17 0 t 38 38 37 98 32 All Exits .- Exit 3 ----- Exit 2 ----Exit 1 34 εε 35 18 30 58 82 114 Probability 0.25 .25 0.45 0.3 0.15 0.05 0.4 0.35 0.1 0

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



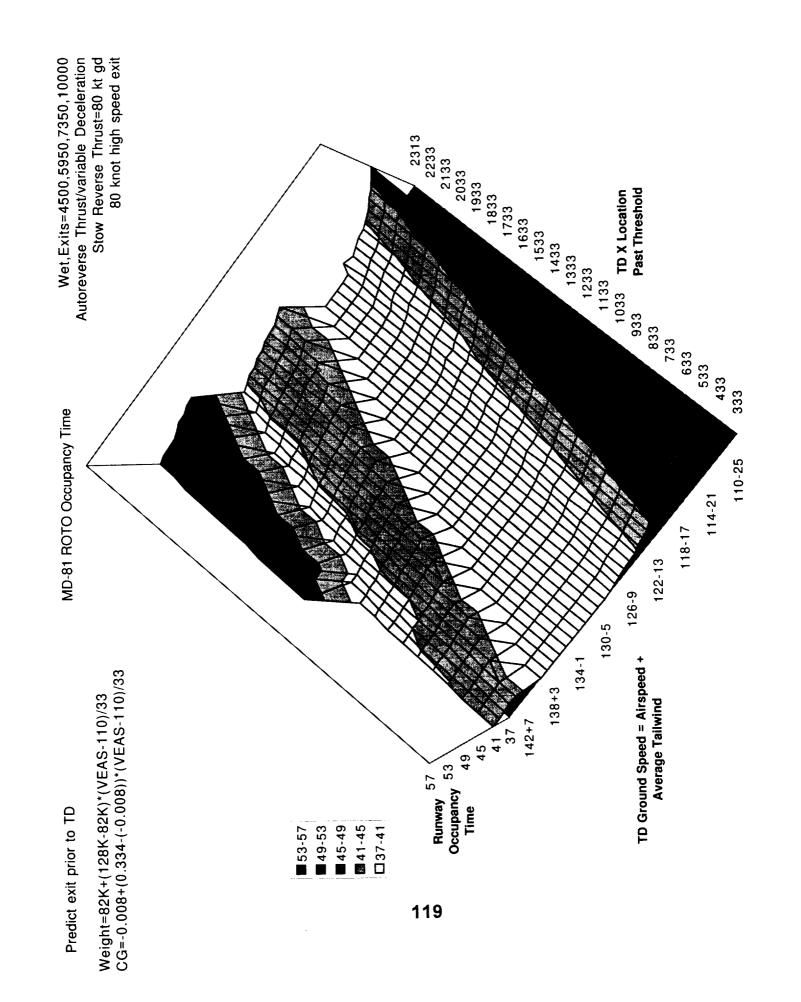
23 25 19 09 6 t 84 L 7 Wet, Auto reverse thrust/variable decel/60 kt exit speed Mean=44.6, STDEV=4.001 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 91 97 MD-81 Runway Occupancy Time (ROT) seconds 45 01 38 38 37 98 32 **⊅**€ All Exits Exit 4 - Exit 1 ----- Exit 2 -- Exit 3 33 35 34 30 58 82 911 Probability 0.25 0.45 0.4 0.35 0.3 0.15 0.1 0.05 0

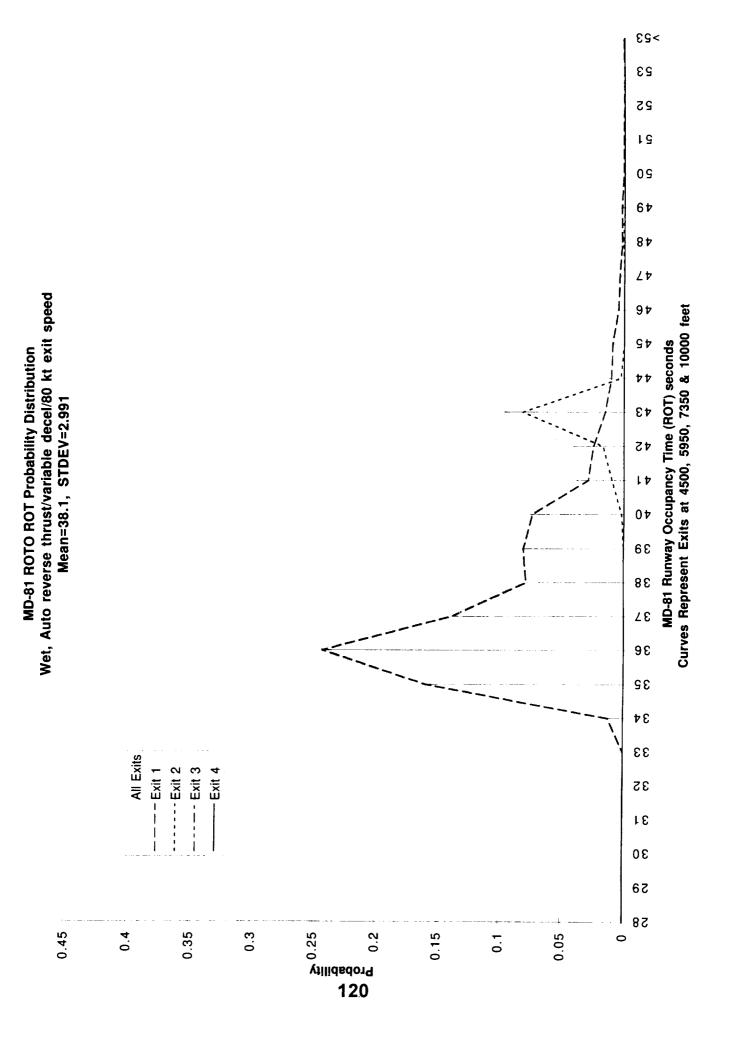
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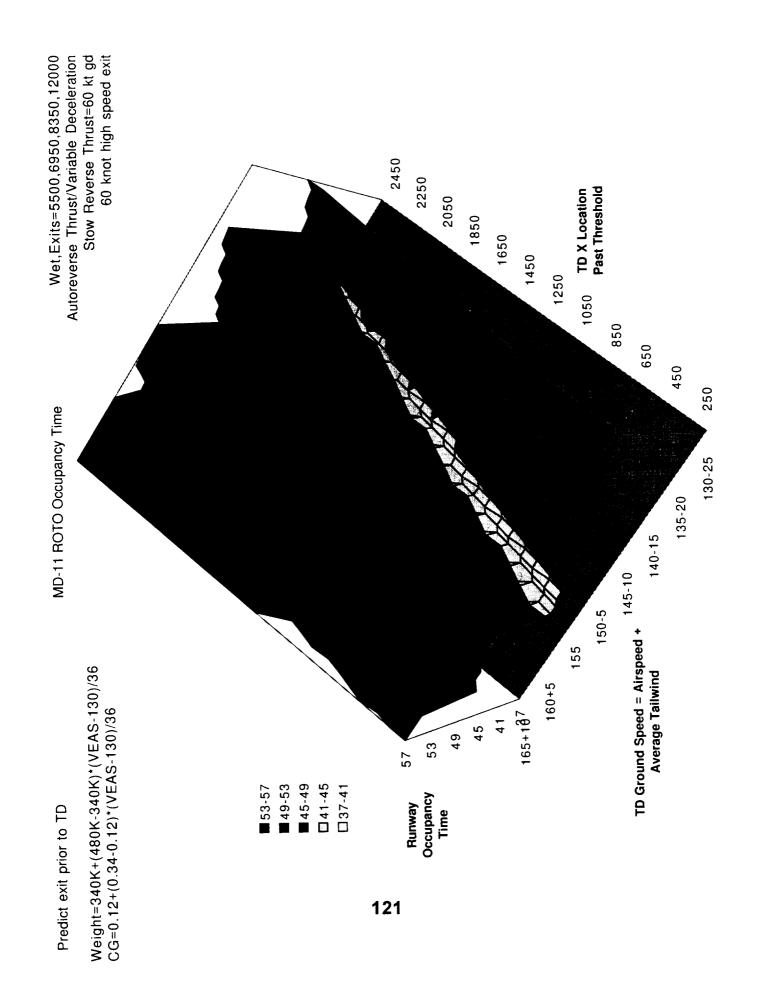


>23 23 25 19 09 6*†* 81 4 Wet, Auto reverse thrust/variable decel/80 kt exit speed Mean=41.8, STDEV=3.78 91 97 **MD-11 ROTO ROT Probability Distribution** t t £ Þ 45 1 7 0 Þ 38 88 ٤٤ 98 32 All Exits .- Exit 3 - Exit 4 ----- Exit 2 ---Exit 1 34 33 35 18 30 58 82 8118 Probability 0.25 0.45 4.0 0.3 0.35 0.15 0.05 0.1 0

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

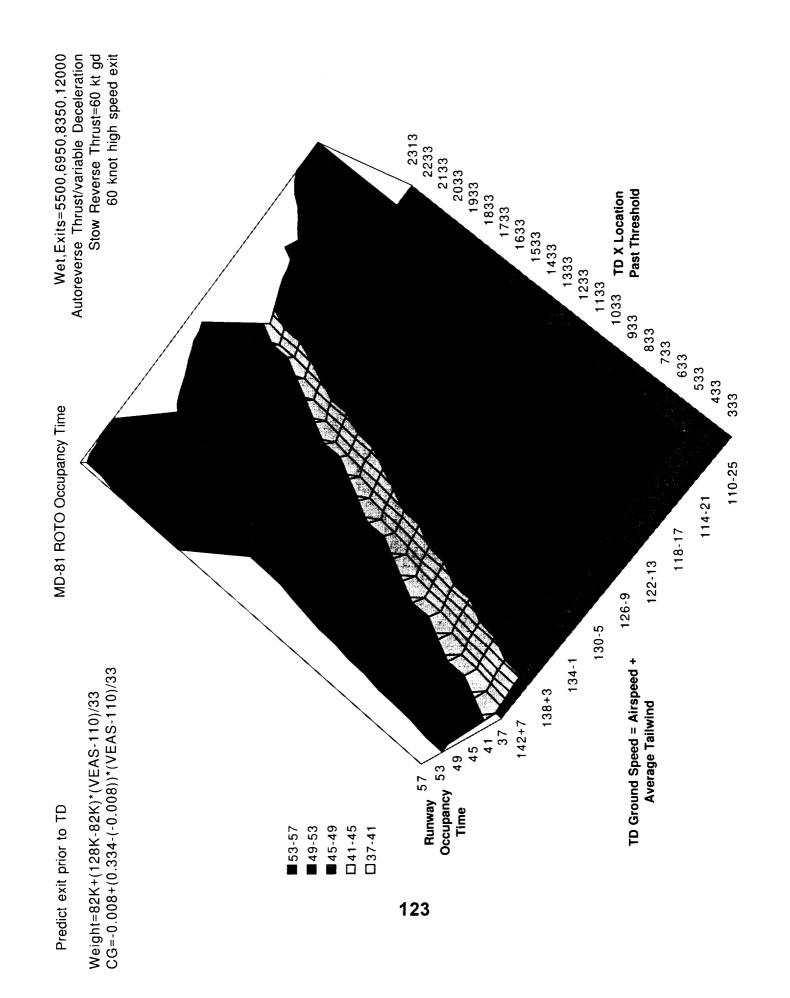






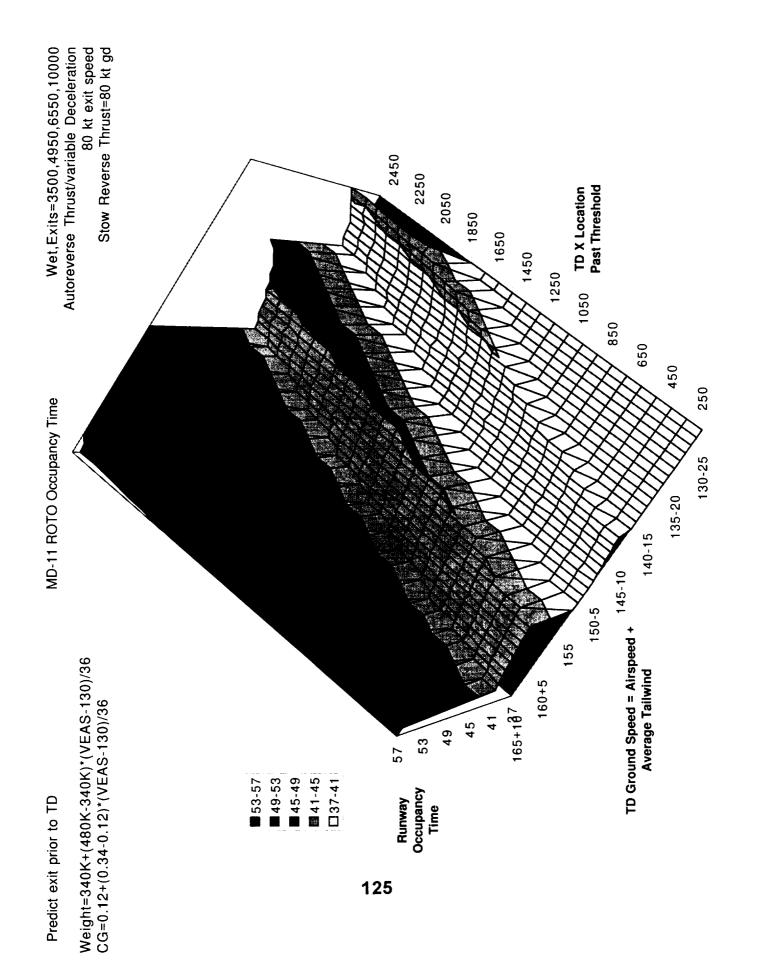
£9< 23 25 19 09 6 Þ 81 L \$ Wet, Auto reverse thrust/variable decel/60 kt exit speed Mean=50.7, STDEV=4.23 91 97 _ママ £ \$ 45 1 7 01 All Exits Exit 4 ----Exit 1 Exit 3 -- Exit 2 36 8£ ۷٤ 98 32 34 33 35 18 30 58 82 122 Villidedora 0.45 0.4 0.35 0.3 0.15 0.1 0.05 0

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 5500, 6950, 8350 & 12000 feet



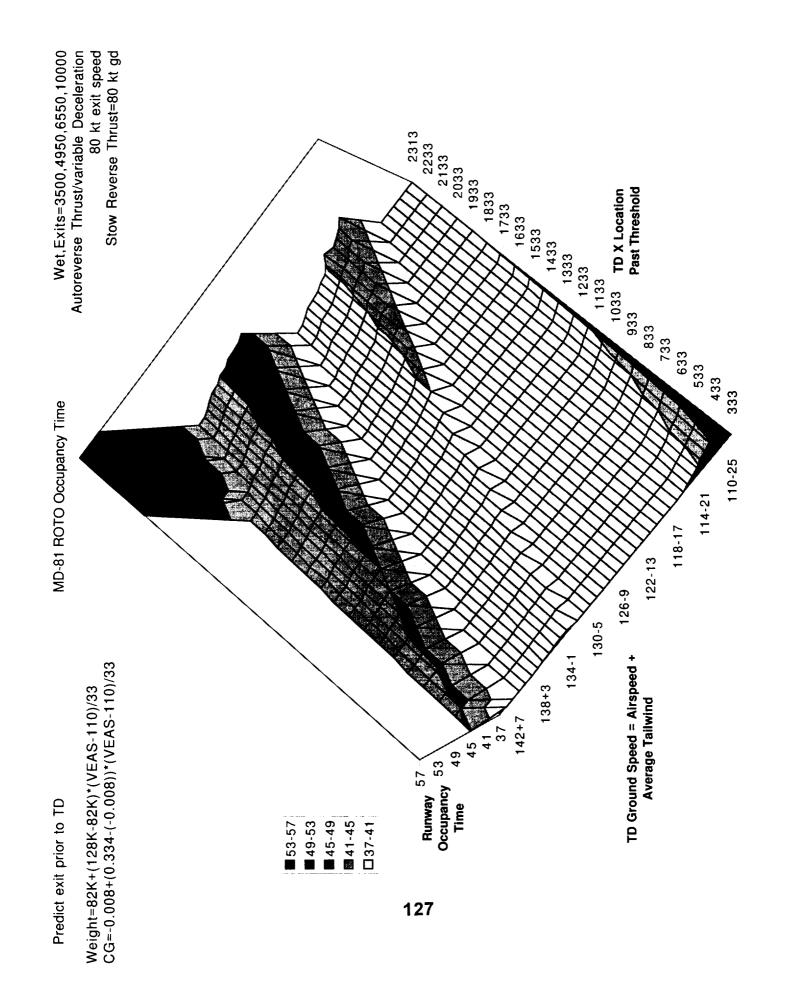
23 25 19 ٥٥ 67 81 ۷7 Wet, Auto reverse thrust/variable decel/60 kt exit speed 91 Curves Represent Exits at 5500, 6950, 8350 & 12000 feet 91 MD-81 Runway Occupancy Time (ROT) seconds Mean=48.8, STDEV=4.041 £ \$ 45 01 38 All Exits - Exit 3 - Exit 4 ----- Exit 2 ----Exit 1 38 **Δ**ε 98 32 34 33 35 34 30 58 82 SS 0 Allildsdorg 0.3 0.45 0.4 0.35 0.15 0.05 0 0.1

۶g<

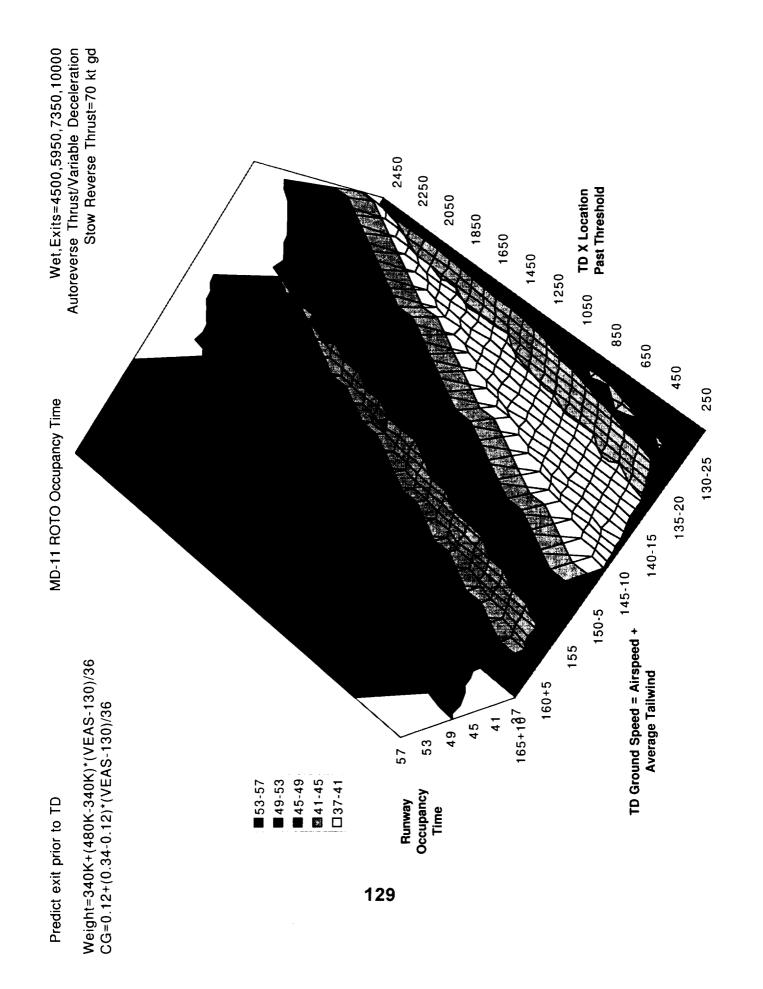


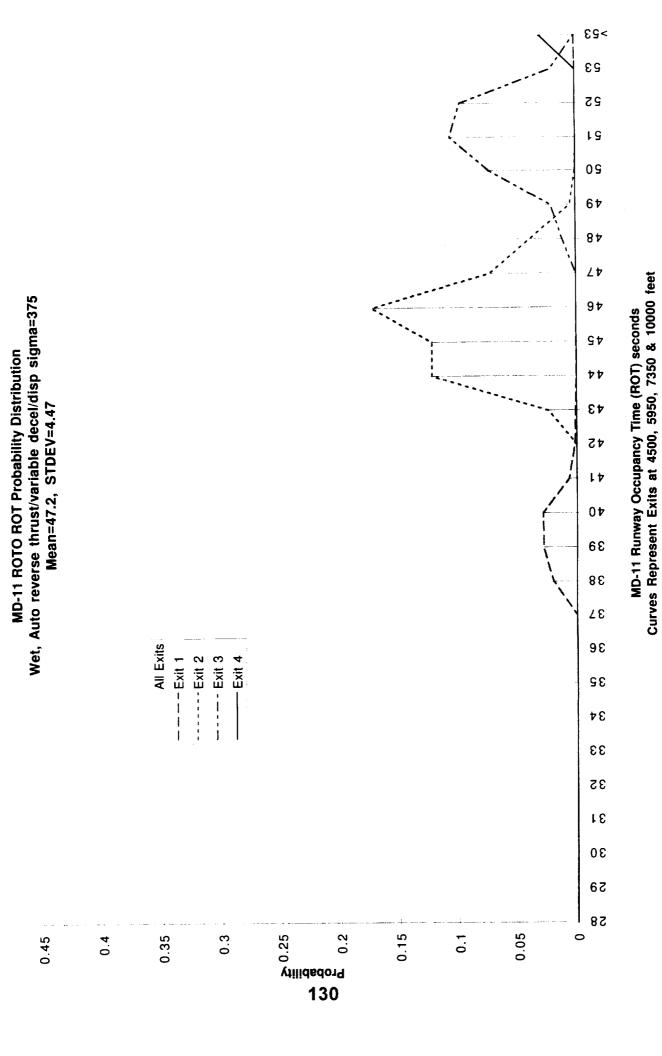
>23 23 25 19 09 6 t 81 ۷Þ Wet, Auto reverse thrust/variable decel/80 kt exit speed Mean=42.8, STDEV=5.64 91 97 t t £ 7 45 10 0 Þ 36 88 All Exits ٤٤ .- Exit 3 ----- Exit 2 -- Exit 1 9ε 32 34 33 35 18 30 58 82 0.45 0.4 0.3 0.15 0.05 0 0.35 0.1

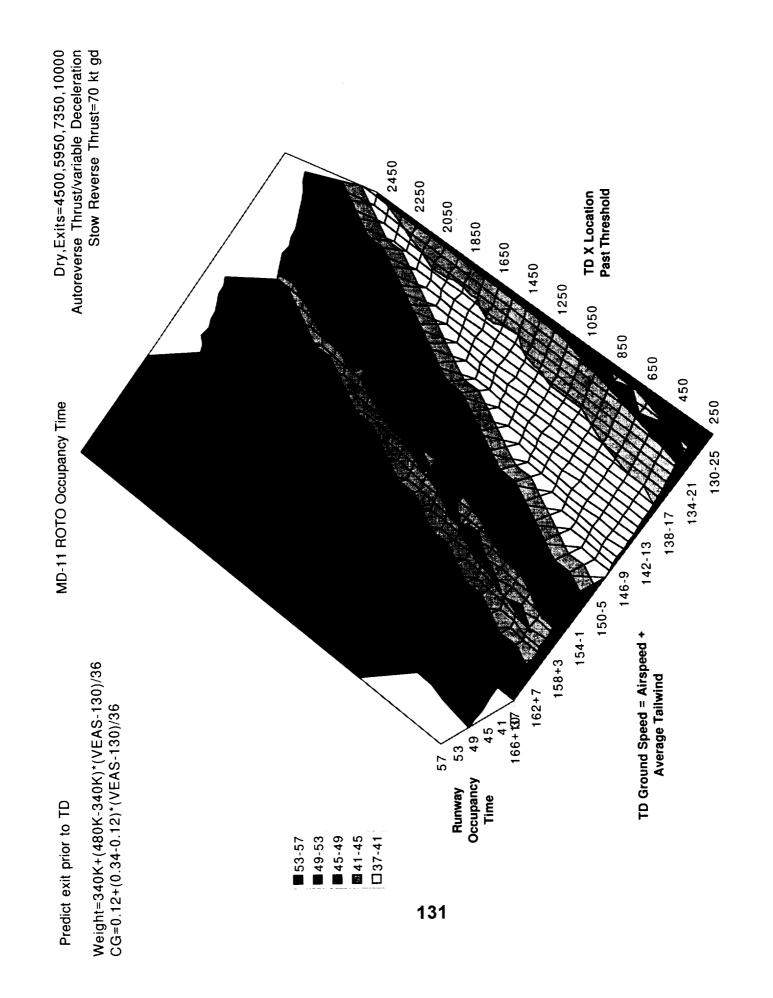
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3500, 4950, 6550 & 10000 feet



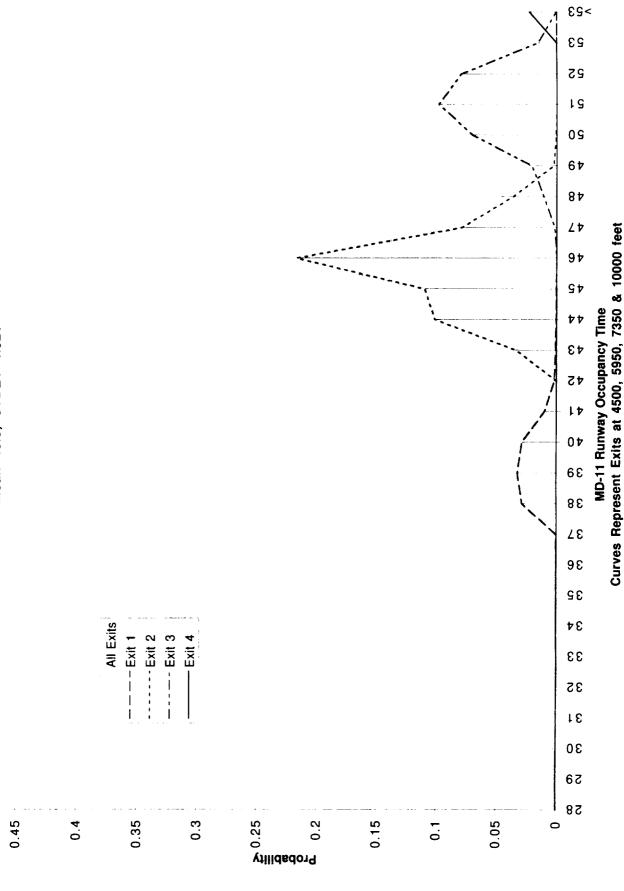
>23 23 25 All Exits 13 - Exit 4 ----- Exit 2 ---Exit 1 ---- Exit 3 09 61 81 **1** Wet, Auto reverse thrust/variable decel/80 kt exit speed Curves Represent Exits at 3500, 4950, 6550 & 10000 feet 91 97 MD-81 Runway Occupancy Time (ROT) seconds Mean=36.1, STDEV=3.893 £ \$ 45 17 0*†* 38 38 3 \ 98 32 **7** € 33 35 15 30 58 82 Probability 0.25 0.45 0.35 0.3 0.05 0.4 0.2 0.15 0.1 0 128

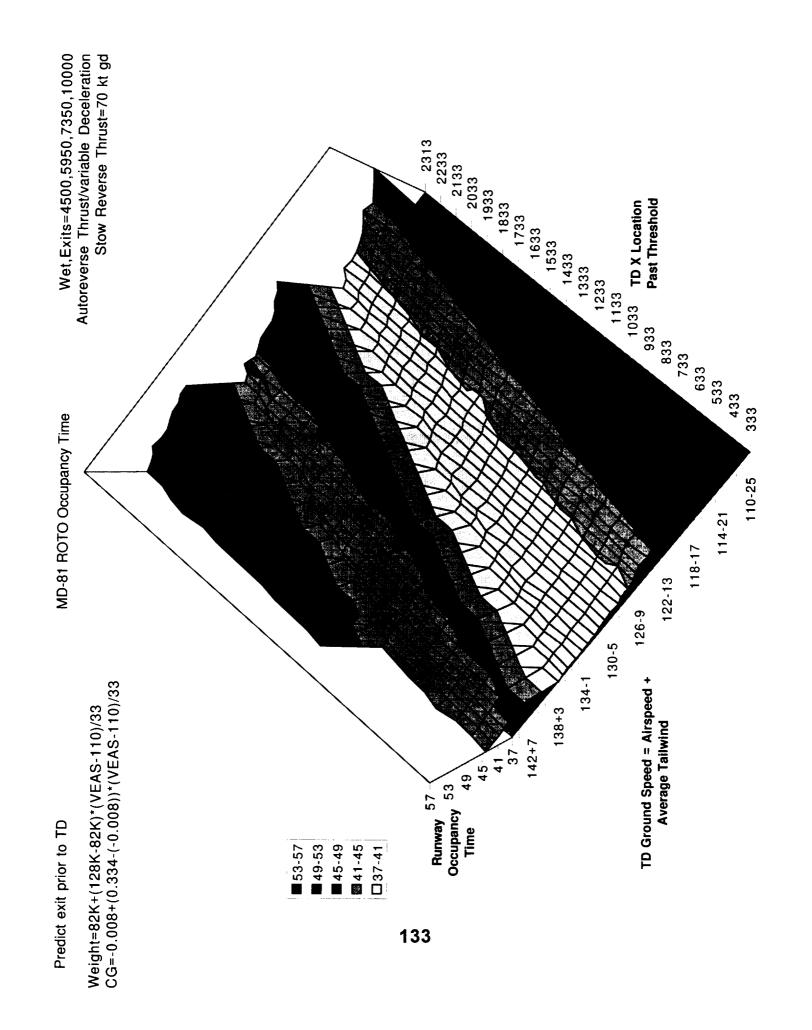






MD-11 ROTO ROT Probability Distribution
Dry, Auto reverse thrust/variable decel/dispersion sigma=375
Mean=46.8, STDEV=4.321



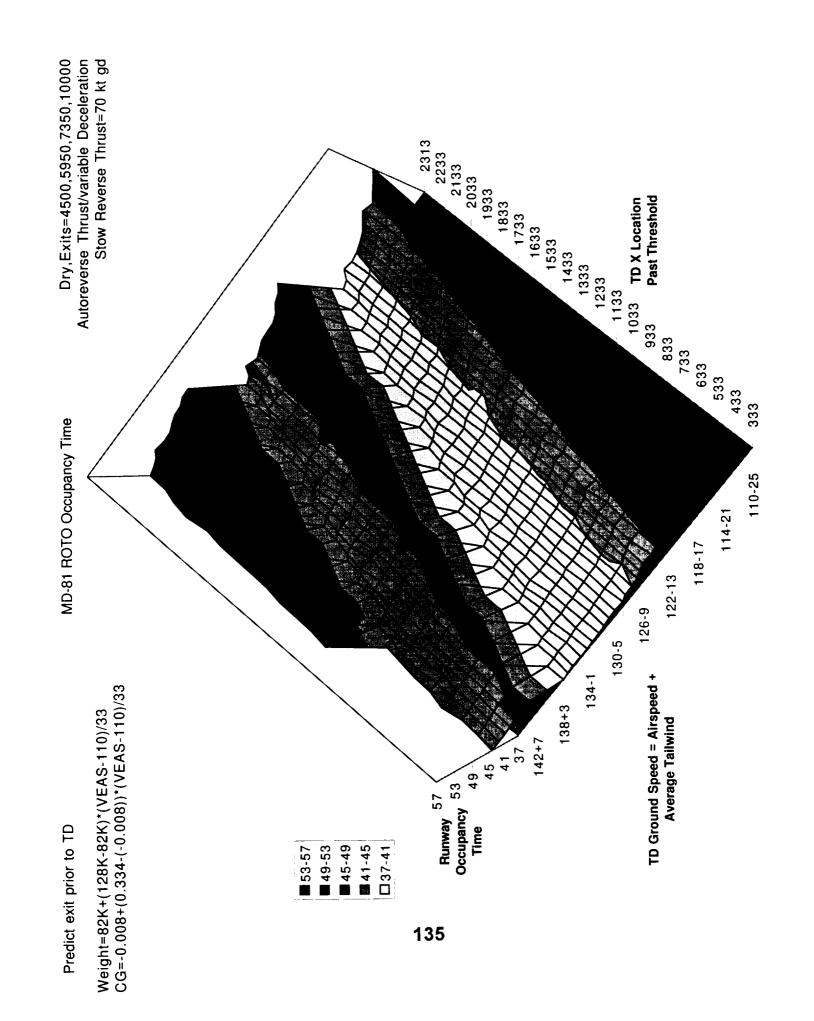


>23 23 25 19 90 6*†* 81 L Þ Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 91 MD-81 Runway Occupancy Time (ROT) seconds 97 £ \$ 38 38 32 98 32 34 All Exits ---Exit 1 ---- Exit 3 - Exit 4 ----- Exit 2 33 35 15 30 58 82 Villidsdor9 0.25 0.05 4.0 0.35 0.3 0.2 0.15 0.1 0 134

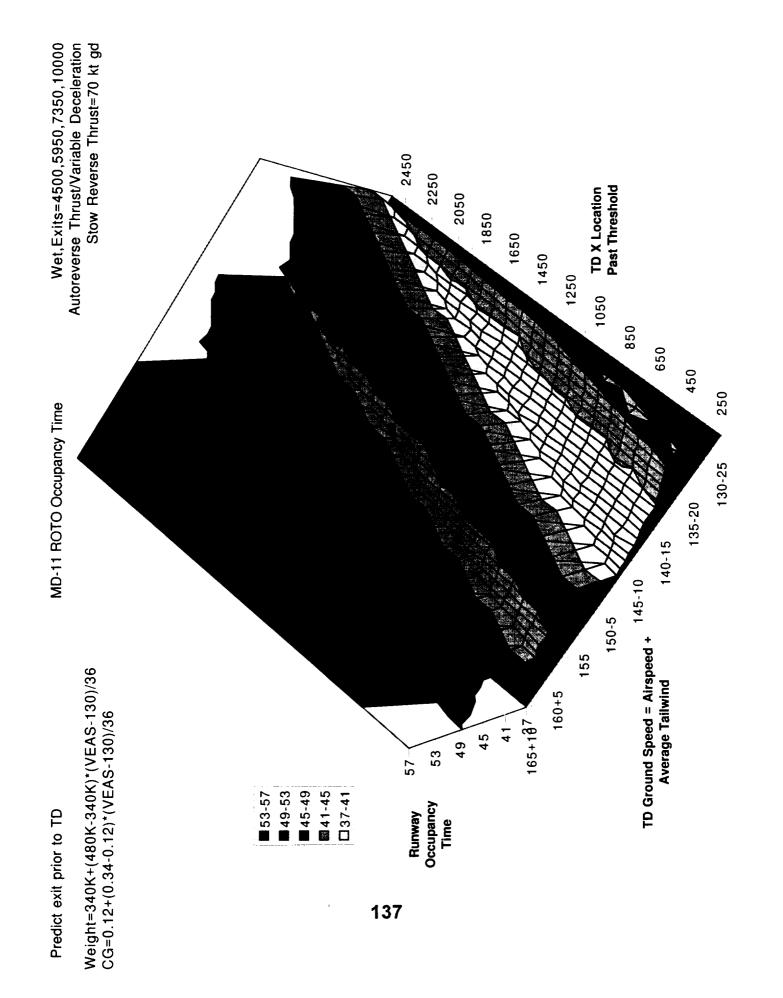
Wet, Auto reverse thrust/variable decel/dispersion sigma=375

Mean=41.5, STDEV=3.381

0.45

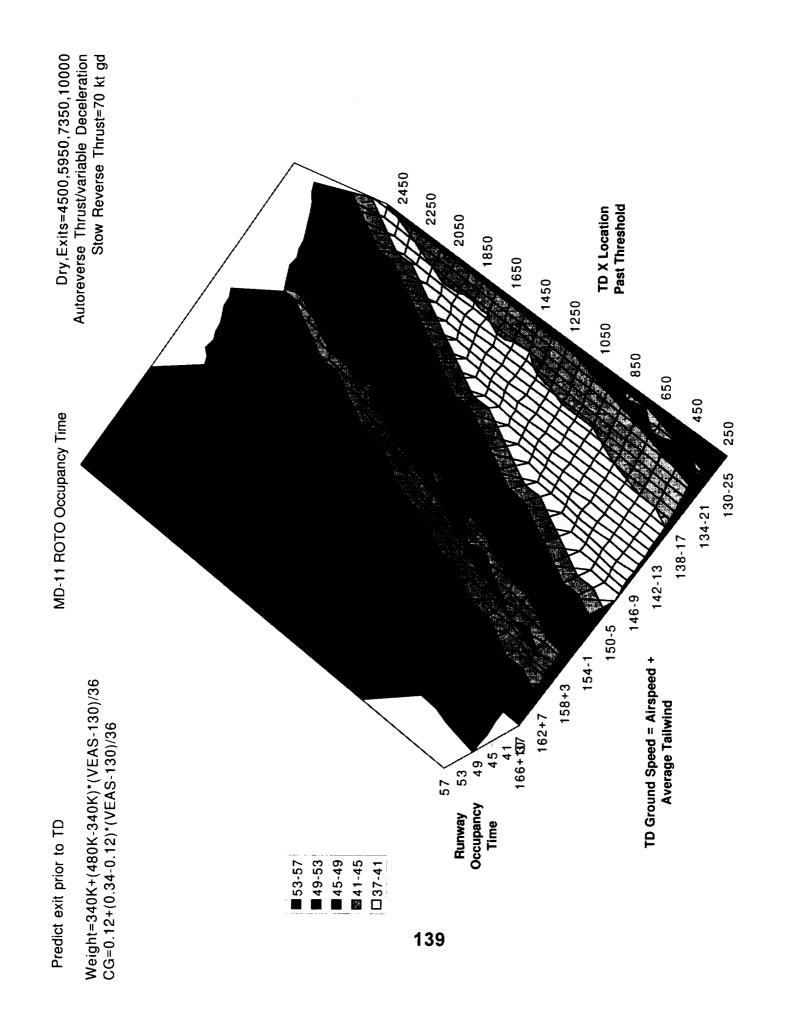


>23 23 25 13 90 6*†* 81 ۷7 Dry, Auto reverse thrust/variable decel/dispersion sigma=375 91 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds Mean=41.5, STDEV=3.381 £ \$ 45 17 0 Þ 38 88 32 98 32 All Exits 34 - Exit 4 -- Exit 1 ---Exit 2 - Exit 3 33 35 34 30 58 82 136 Villidedora 0.25 5. 0.45 0.4 0.35 0.3 0.15 0.05 0.1 0

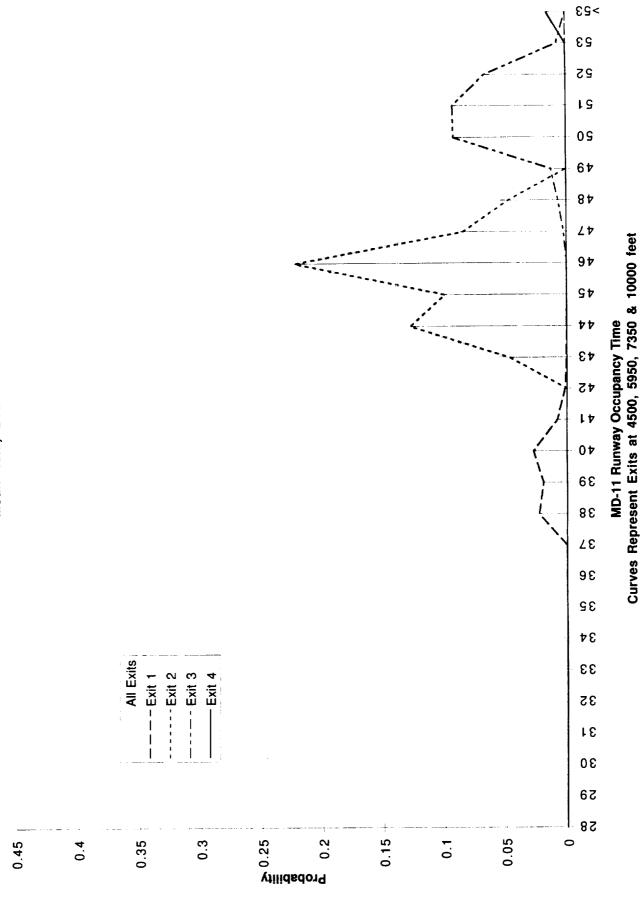


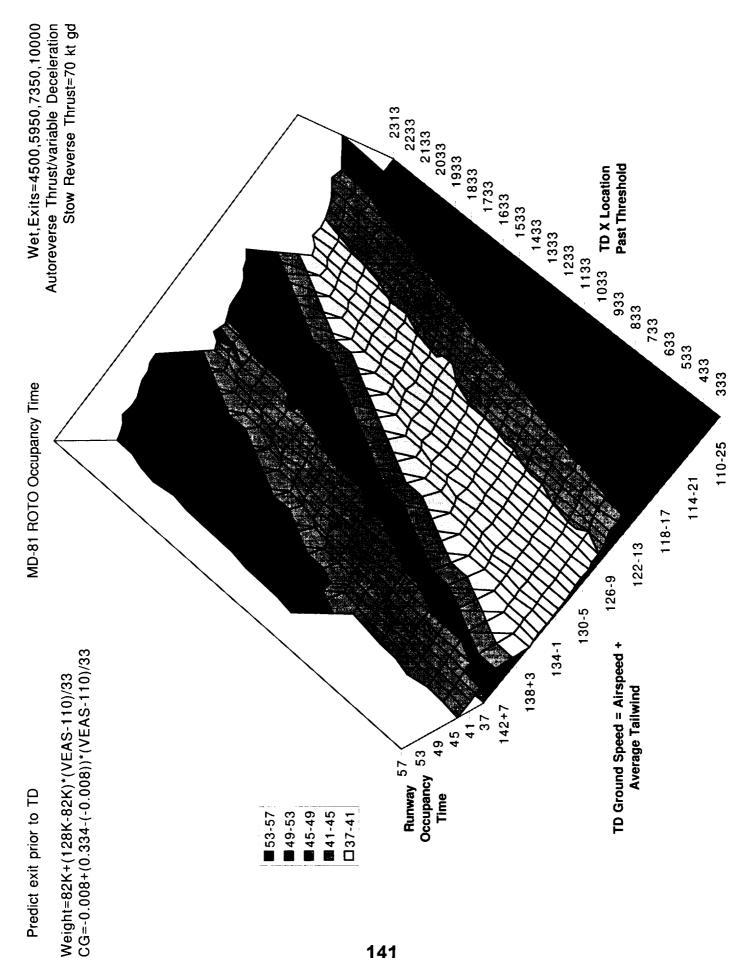
>23 23 25 19 09 61 81 ۷*۲* Wet, Auto reverse thrust/variable decel/dispersion sigma=100 Mean=47.2, STDEV=4.02 91 97 t t £\$ 45 17 01 38 88 32 98 All Exits - Exit 4 ----- Exit 3 ----- Exit 2 ----Exit 1 32 34 33 35 18 30 58 82 8ET Probability 0.05 0.15 0.35 0.3 0 0.1 0.45 0.4

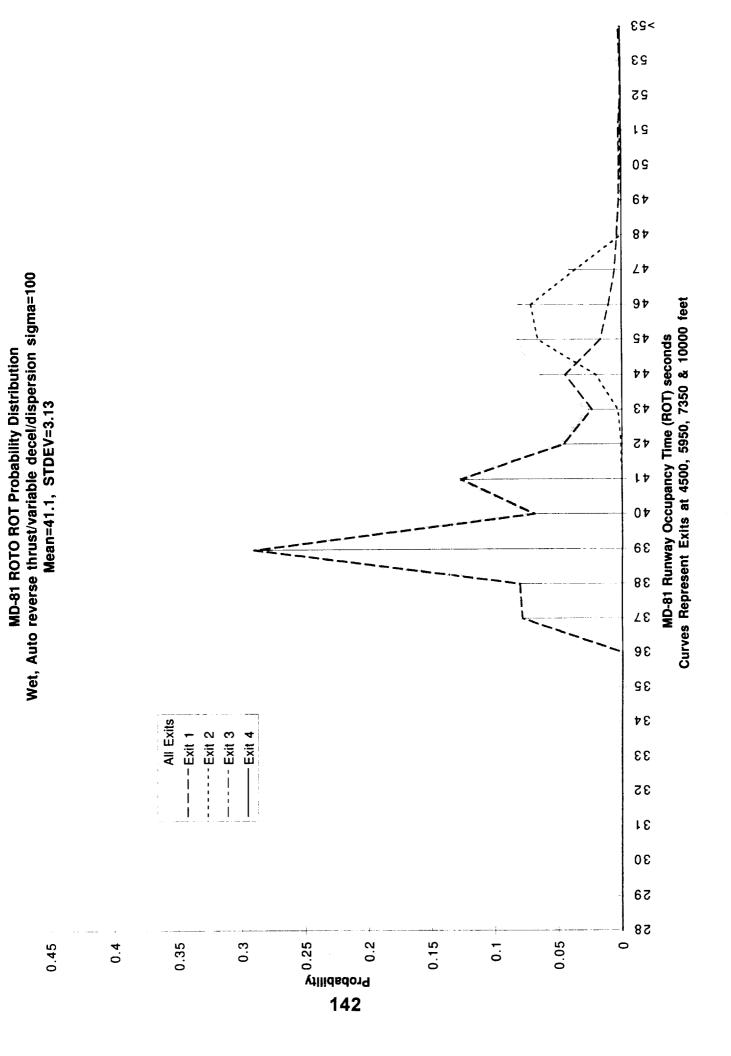
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

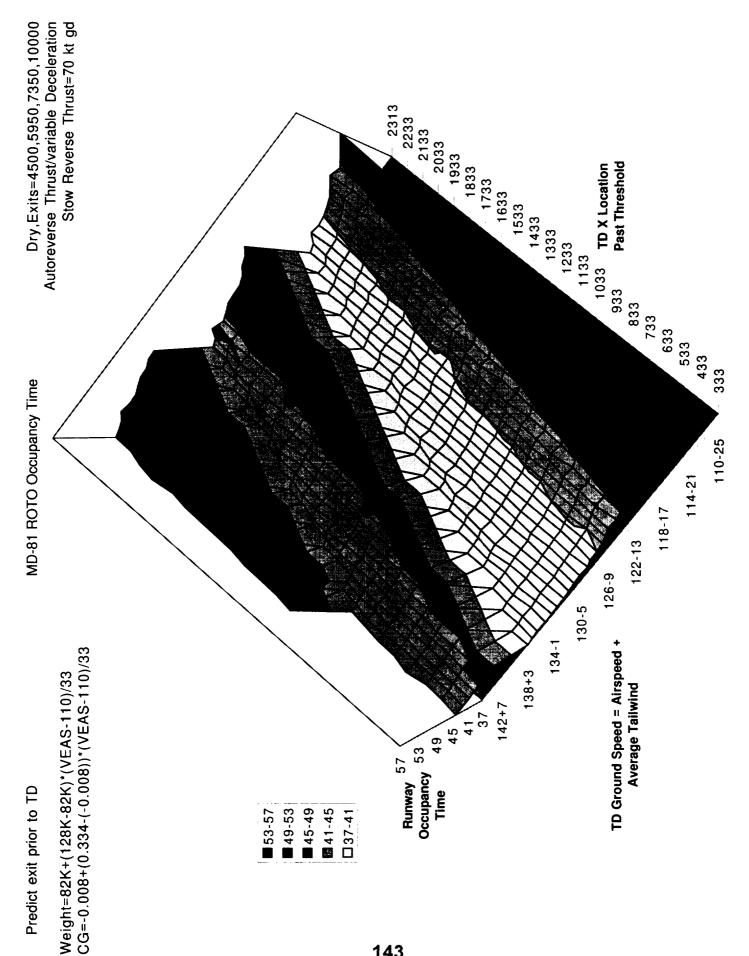


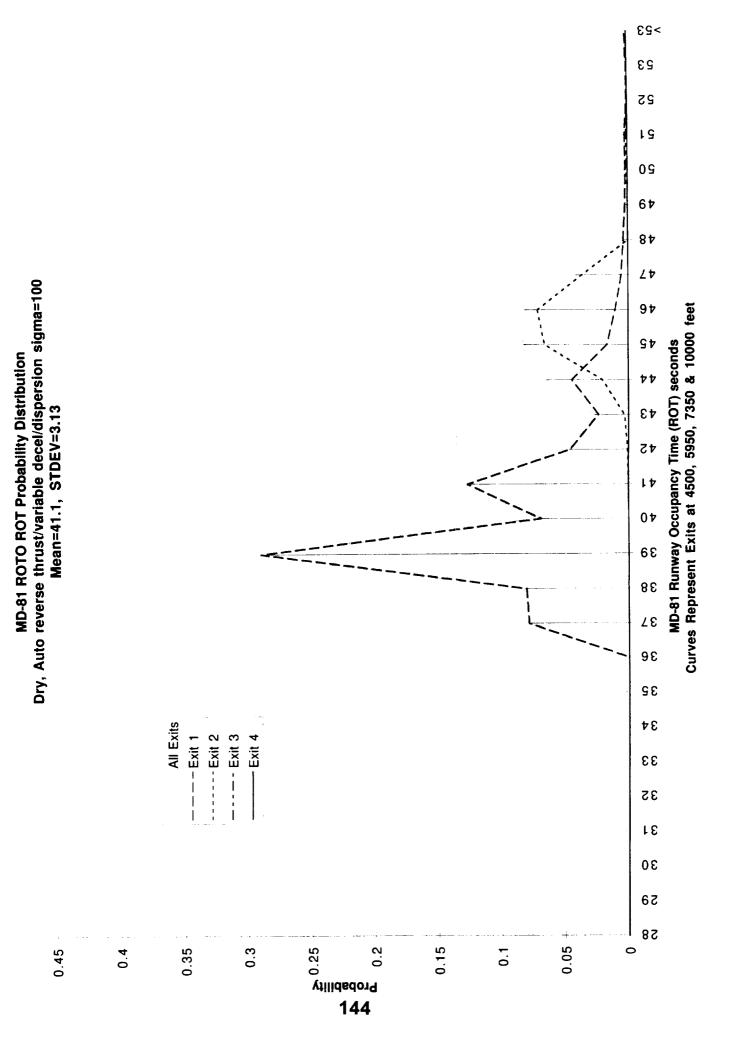
MD-11 ROTO ROT Probability Distribution Dry, Auto reverse thrust/variable decel/dispersion sigma=100 Mean=46.7, STDEV=3.871

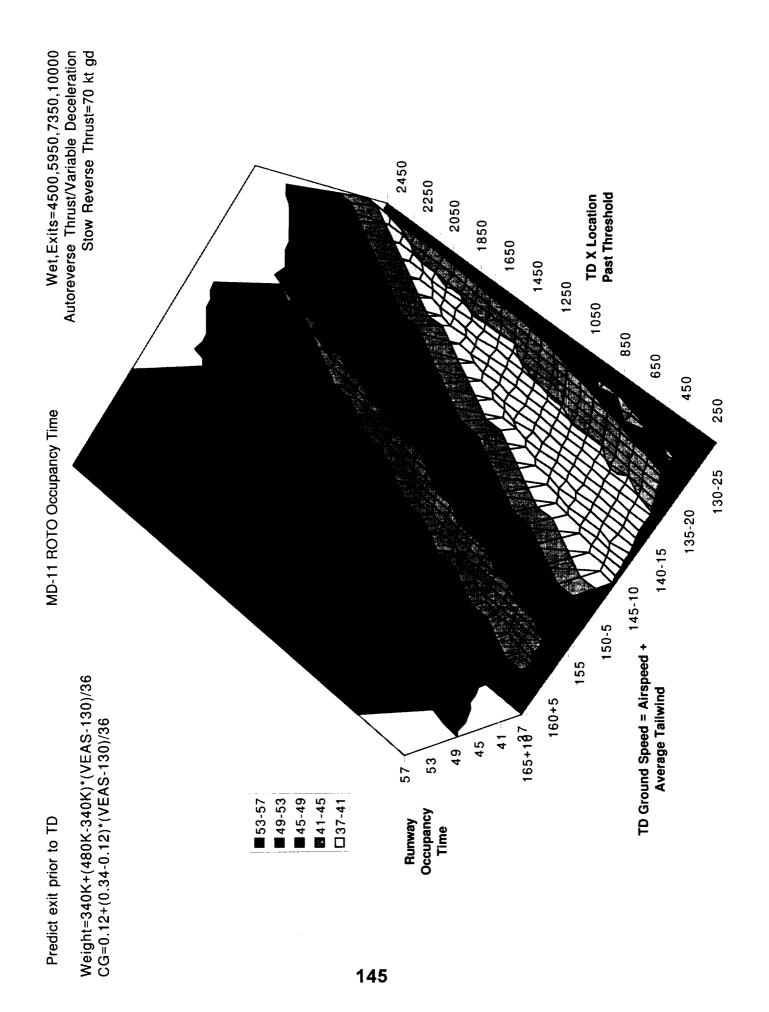








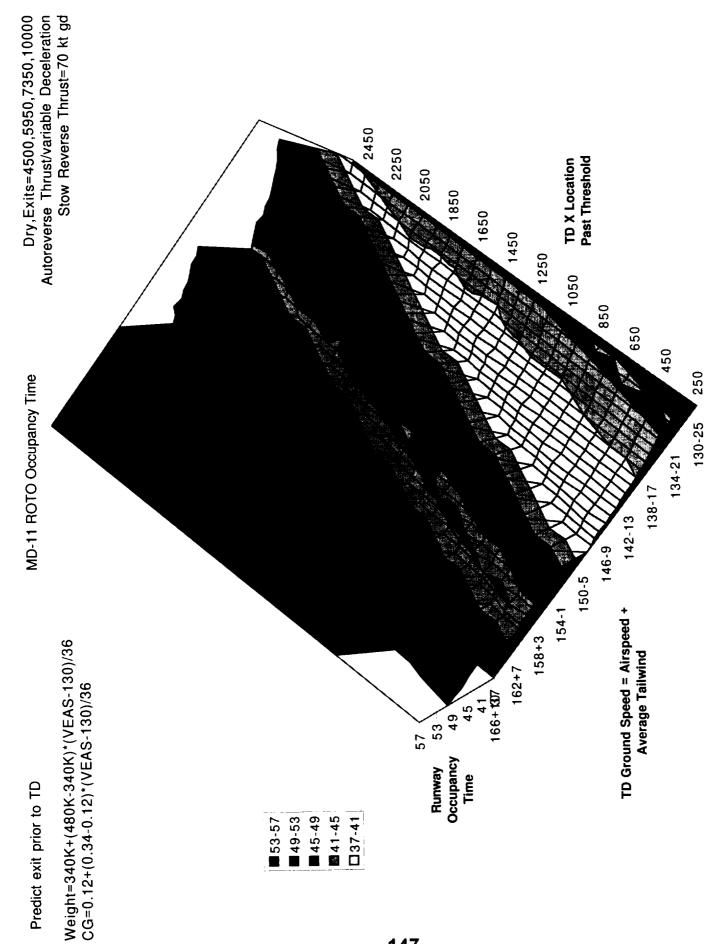




۲ Wet, Auto reverse thrust/variable decel/gnd speed sigma=17 Mean=47.6, STDEV=5.49 t t All Exits Exit 4 ----- Exit 2 ----- Exit 3 ----Exit 1 Villidadora 25 0.15 0.05 0.3 0.45 0.4 0.35 0.1

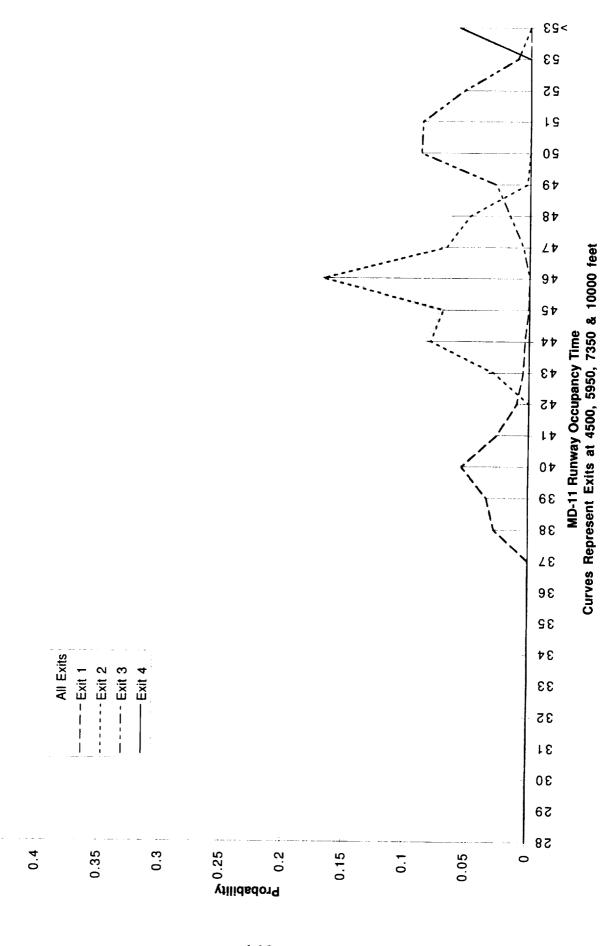
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

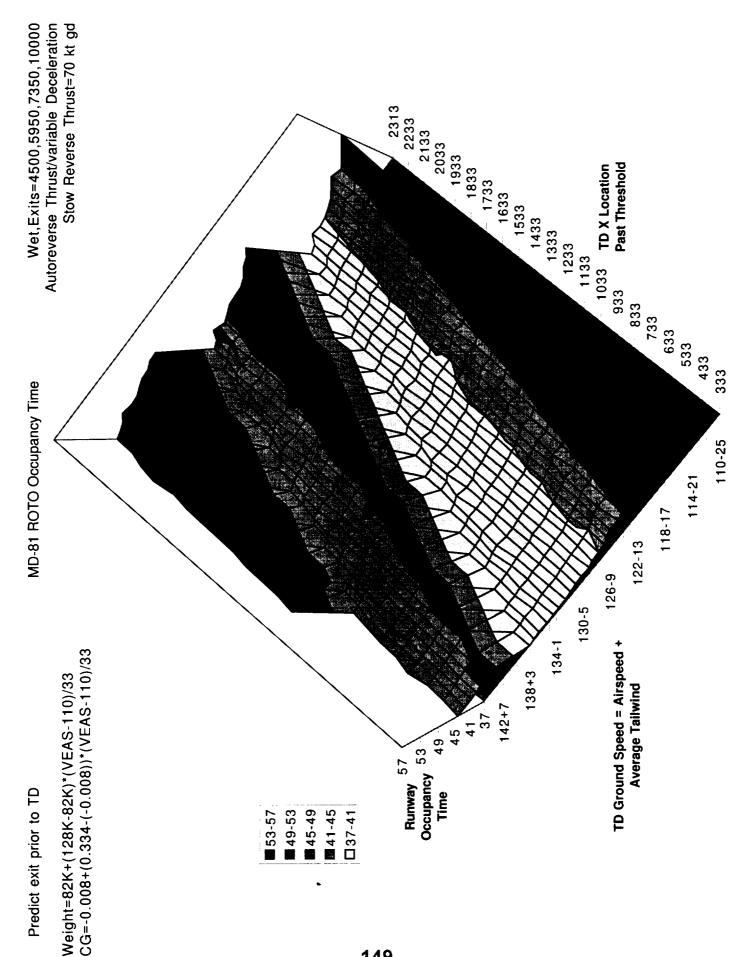
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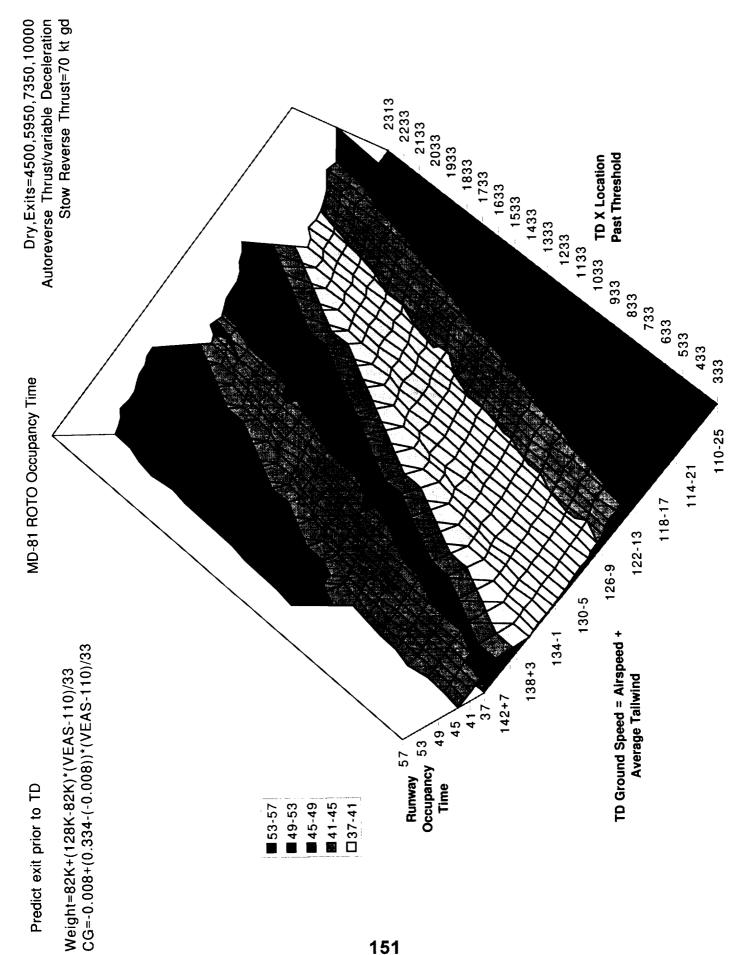
MD-11 ROTO ROT Probability Distribution Dry, Auto reverse thrust/variable decel/gnd speed sigma=17 Mean=47.1, STDEV=5.302

0.45





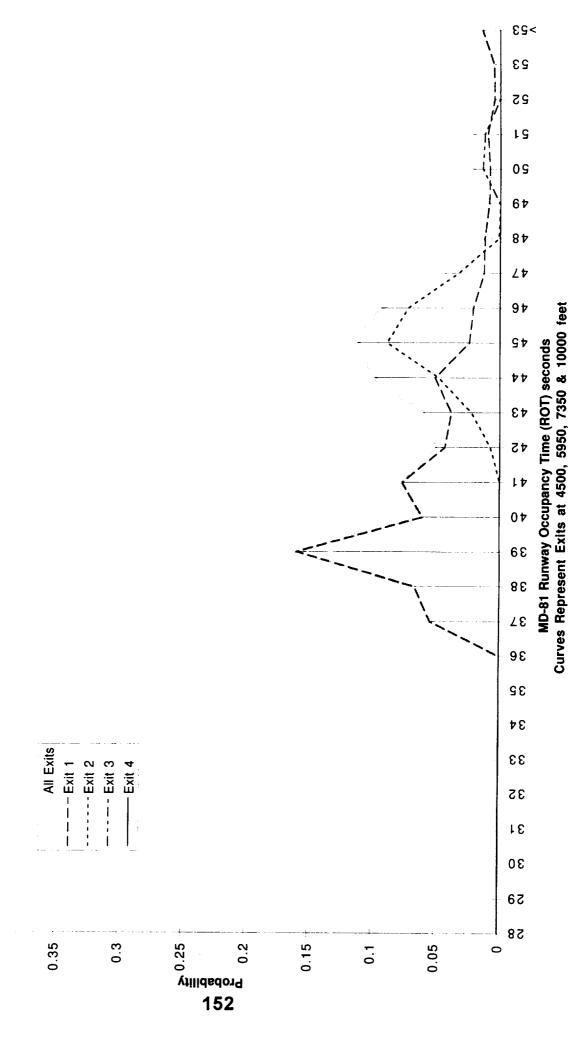
29< 23 25 13 09 61 84 ۷4 Wet, Auto reverse thrust/variable decel/gnd speed sigma=17 Mean=42.7, STDEV=3.972 91 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet MD-81 Runway Occupancy Time (ROT) seconds €⊅ 45 38 38 3 2 98 32 34 All Exits Exit 4 ----- Exit 2 ----- Exit 3 ----Exit 1 33 35 15 30 58 82 Villidadora Probability ... 0.45 0.4 0.35 0.3 0.15 0.05 0.1 0

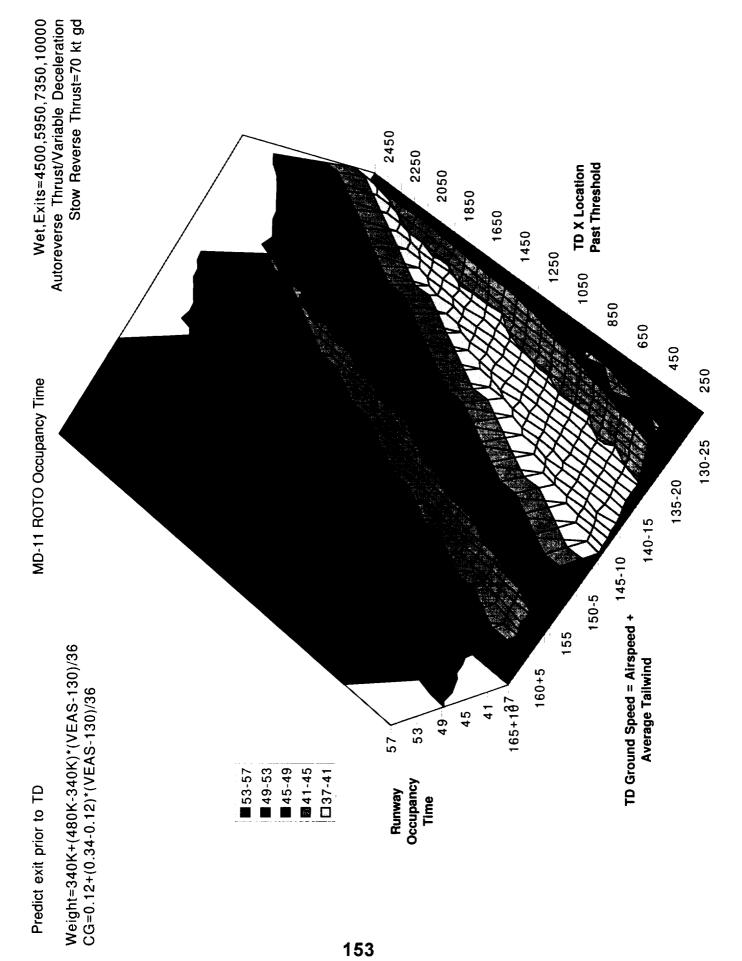


Dry, Auto reverse thrust/variable decel/gnd speed sigma=17 Mean=42.7, STDEV=3.972 MD-81 ROTO ROT Probability Distribution

0.45

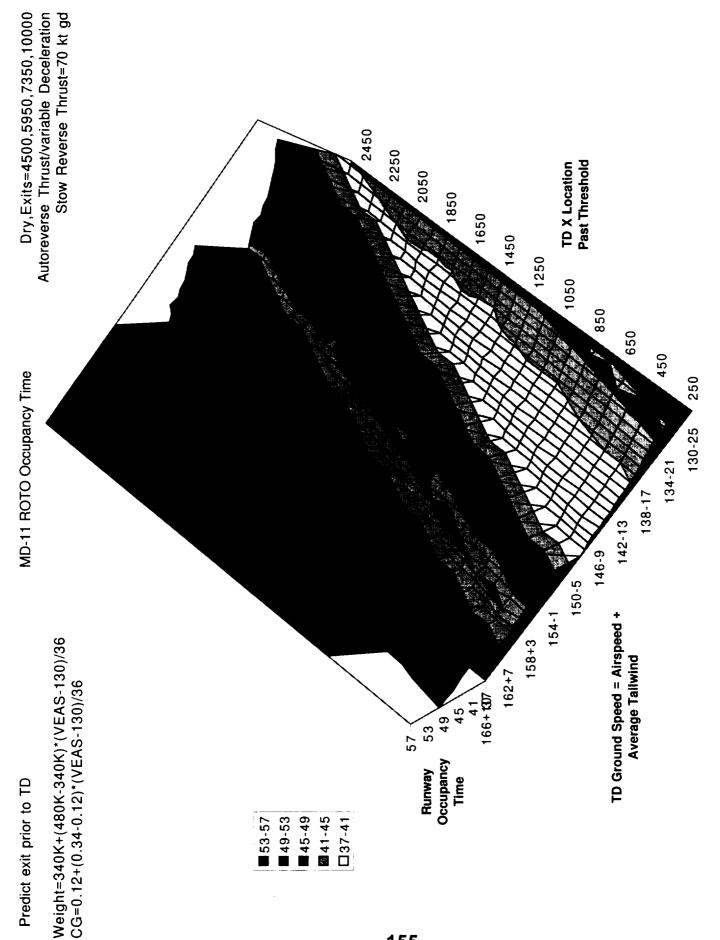
0.4





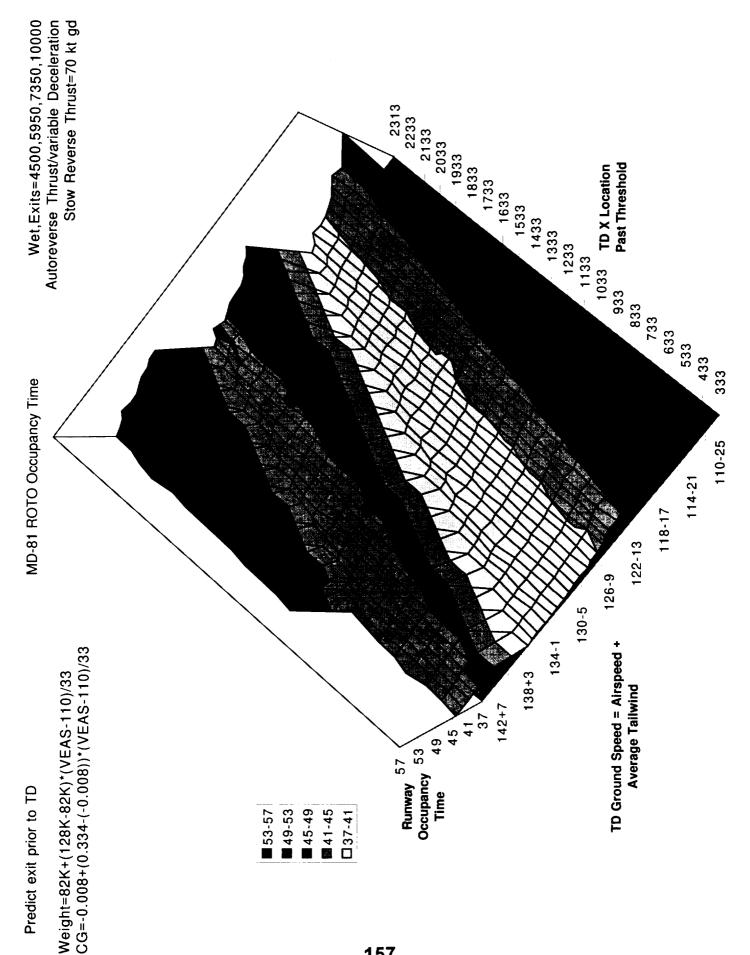
>23 23 25 19 09 6*t* 84 L 7 91 Wet, Auto reverse thrust/variable decel/gnd speed=5 Mean=46.4, STDEV=3 97 43 45 01 38 38 37 98 All Exits 32 ----- Exit 2 ----- Exit 3 ---Exit 1 7 t 33 35 15 30 58 82 Villidadorq 0.15 0.05 0.35 0.3 0 0.45 0.4 0.1

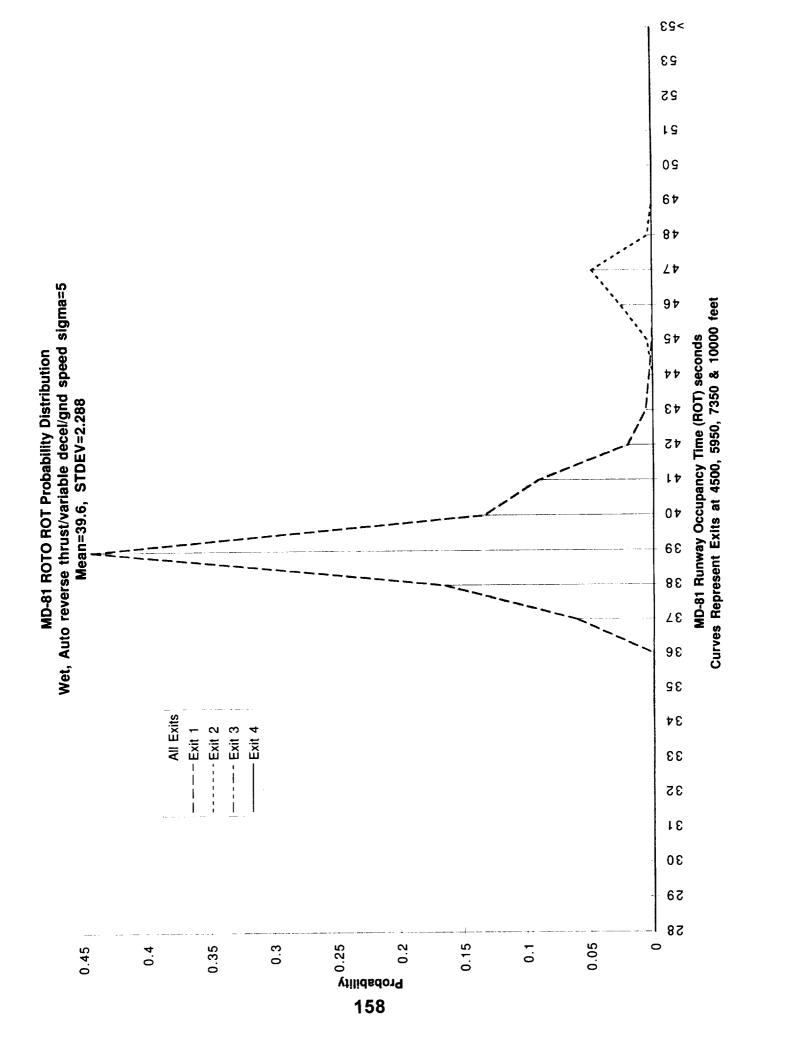
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

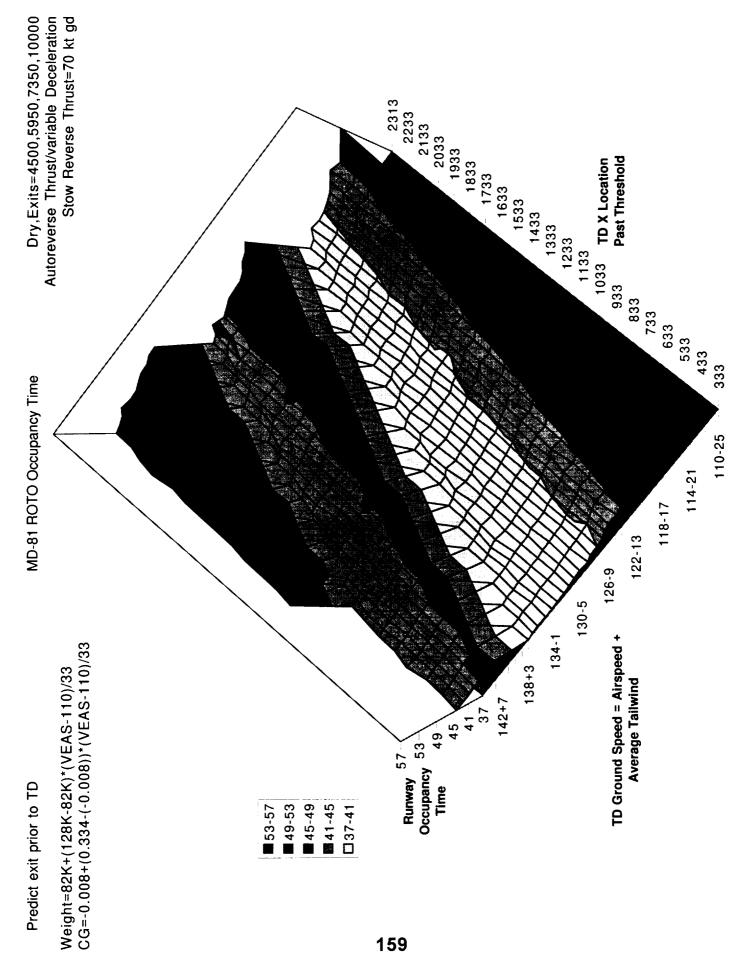


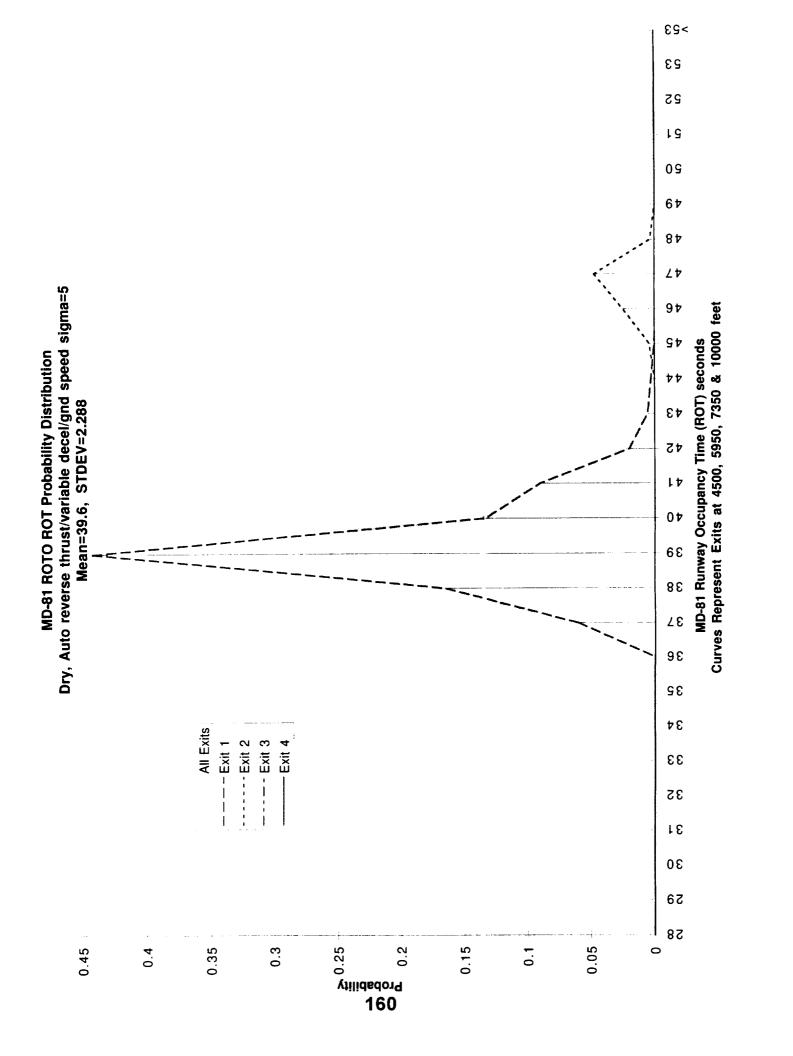
23 25 19 09 Dry, Auto reverse thrust/variable decel/gnd speed sigma=5 Mean=46.1, STDEV=2.629 6 γ 8 9 0 τ 8 6 γ 4 Δ Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 32 All Exits **7** € .- Exit 3 - Exit 1 -- Exit 2 33 35 15 30 58 82 Villdsdor9 0.15 0.05 0.35 0.3 0.2 0 0.45 0.1 0.4

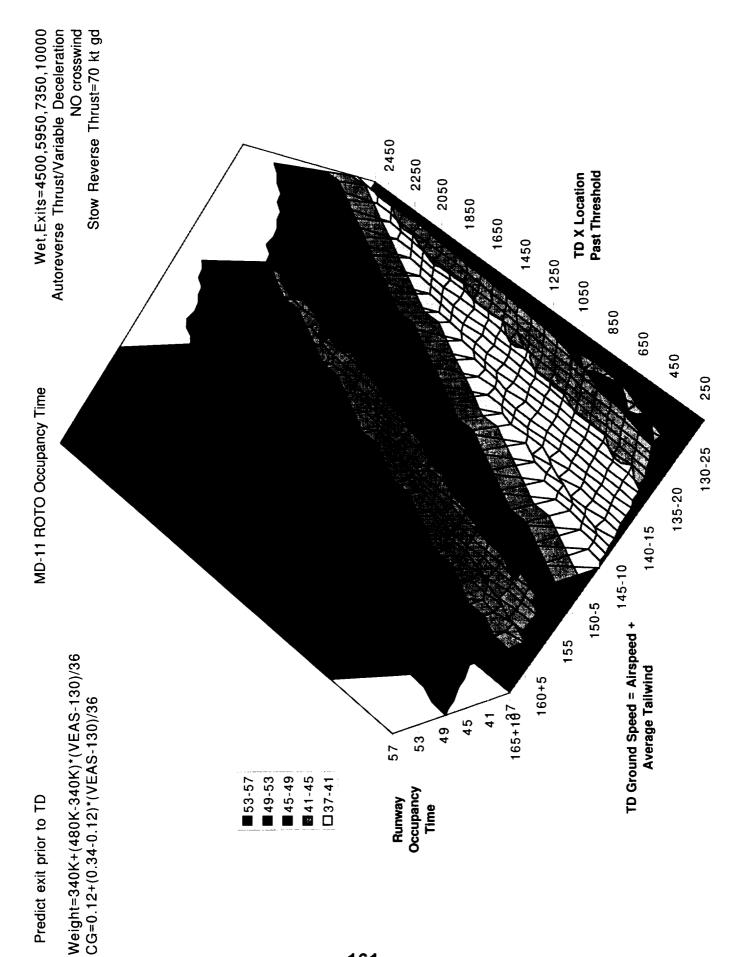
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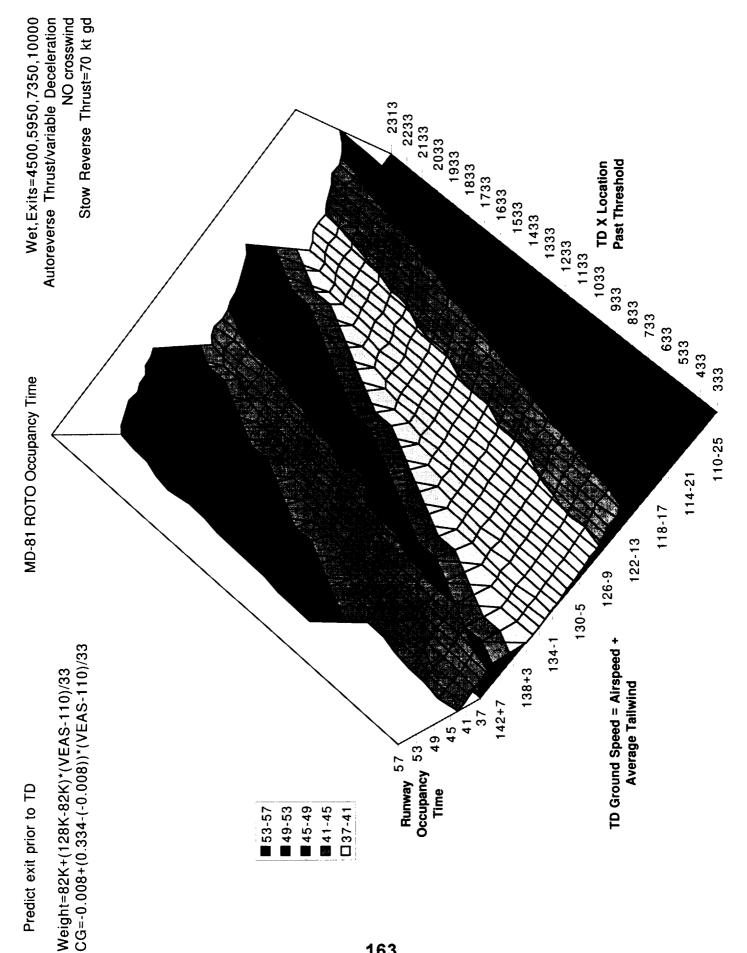






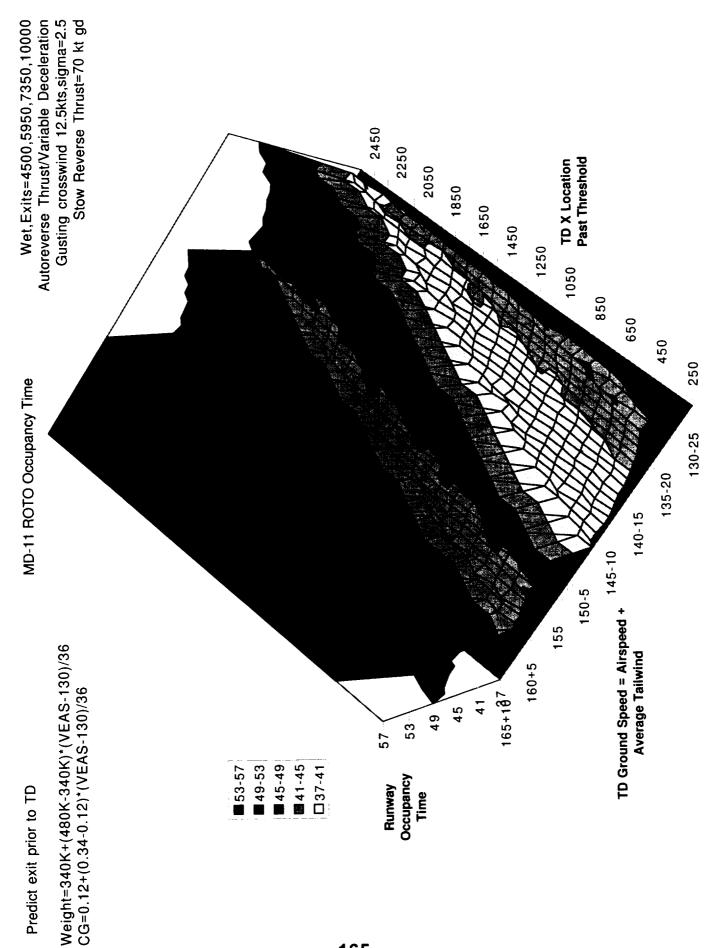
>23 23 25 19 09 6*t* 81 ۷7 Wet, Auto reverse thrust/variable decel/no crosswind Mean=46.7, STDEV=4.09 97 91 t t 43 45 17 01 38 88 ٤٤ 98 32 All Exits Exit 4 ----- Exit 2 - Exit 3 . - Exit 1 34 33 35 15 30 58 82 Probability 0.25 0.15 0.05 0.35 0.3 0.45 0.4 0.1 0 162

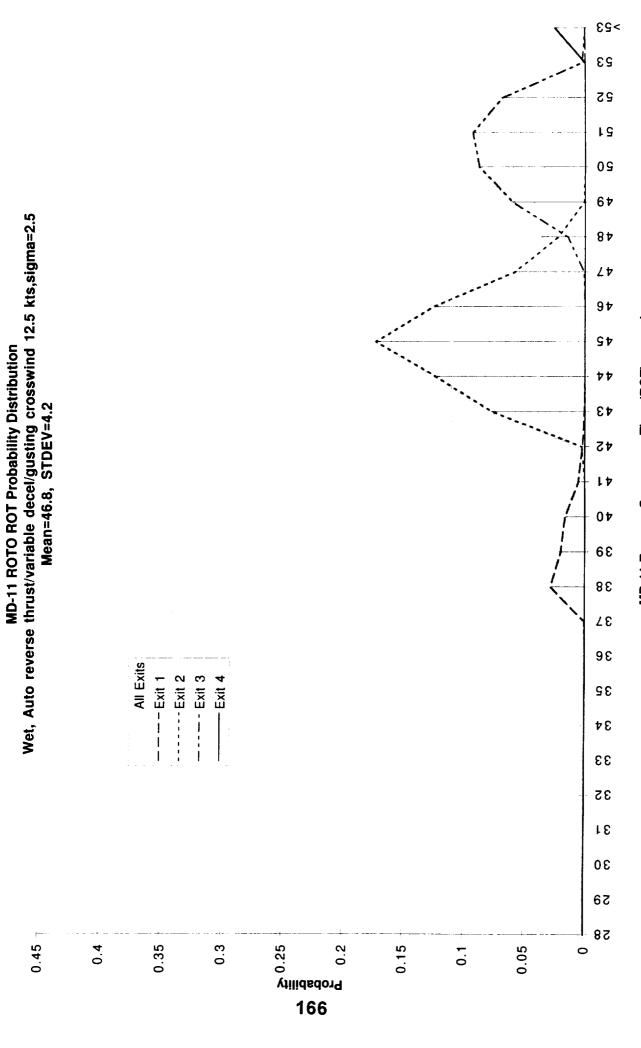
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



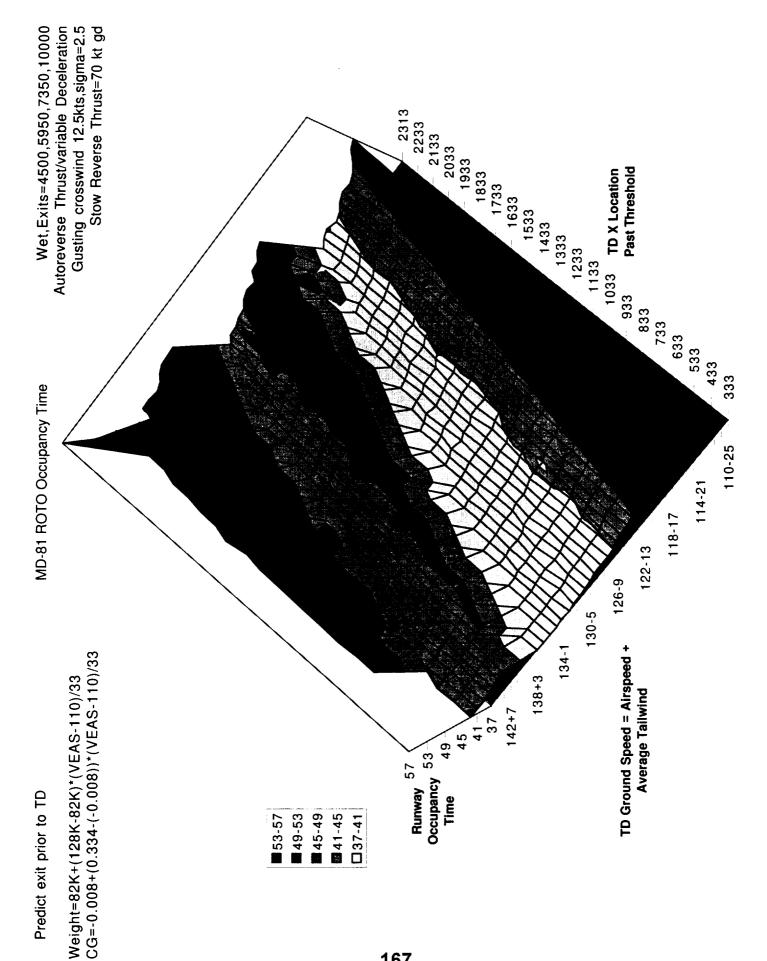
23 25 19 09 6*†* 81 14 Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 97 Wet, Auto reverse thrust/variable decel/no crosswind Mean=41.1, STDEV=3.258 97 MD-81 Runway Occupancy Time (ROT) seconds 01 39 38 3٤ 98 32 34 All Exits Exit 4 Exit 3 --- Exit 2 -- Exit 1 33 35 18 30 58 88 Villidador¶ 0.05 0.15 0 0.3 0.2 0.1 0.45 0.4 0.35 164

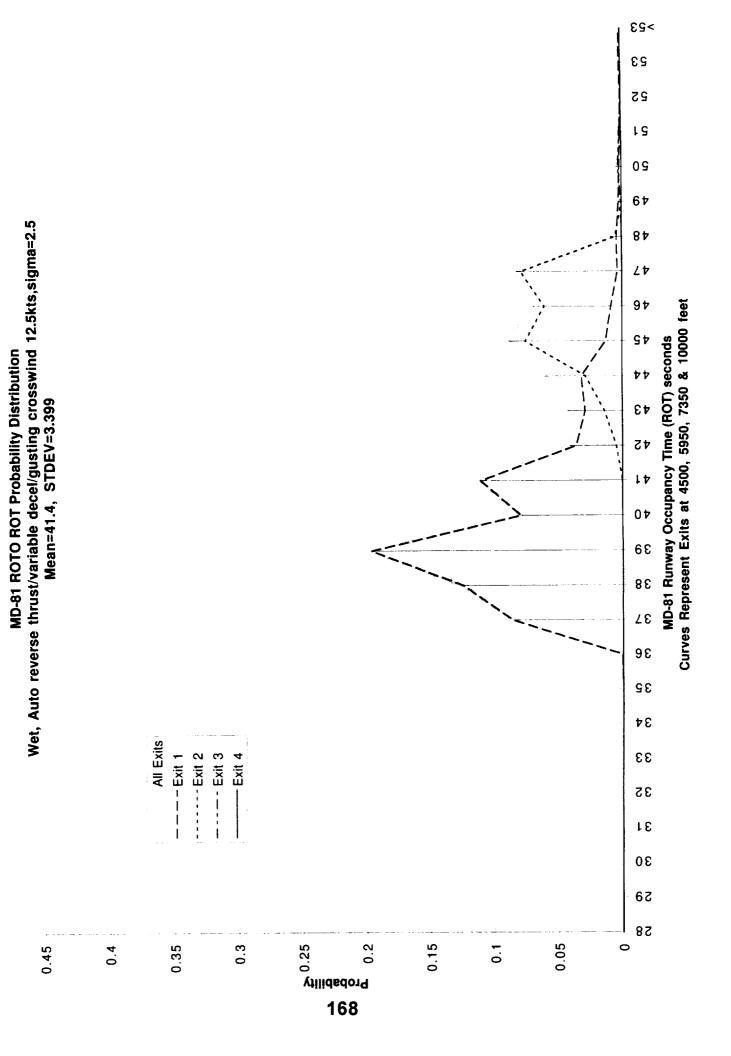
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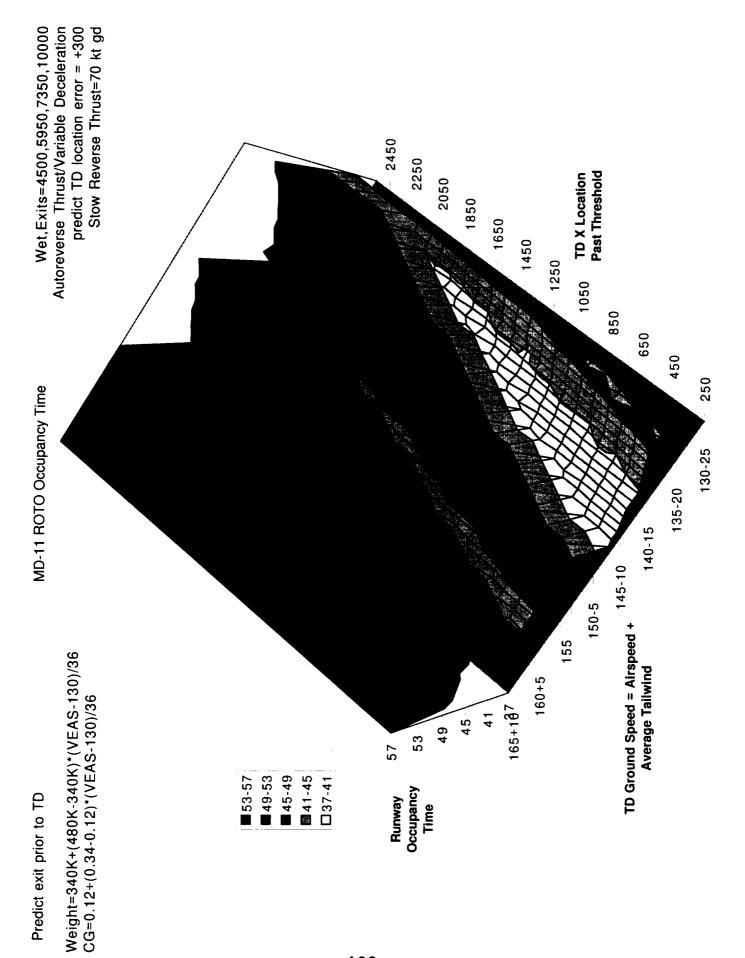




MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

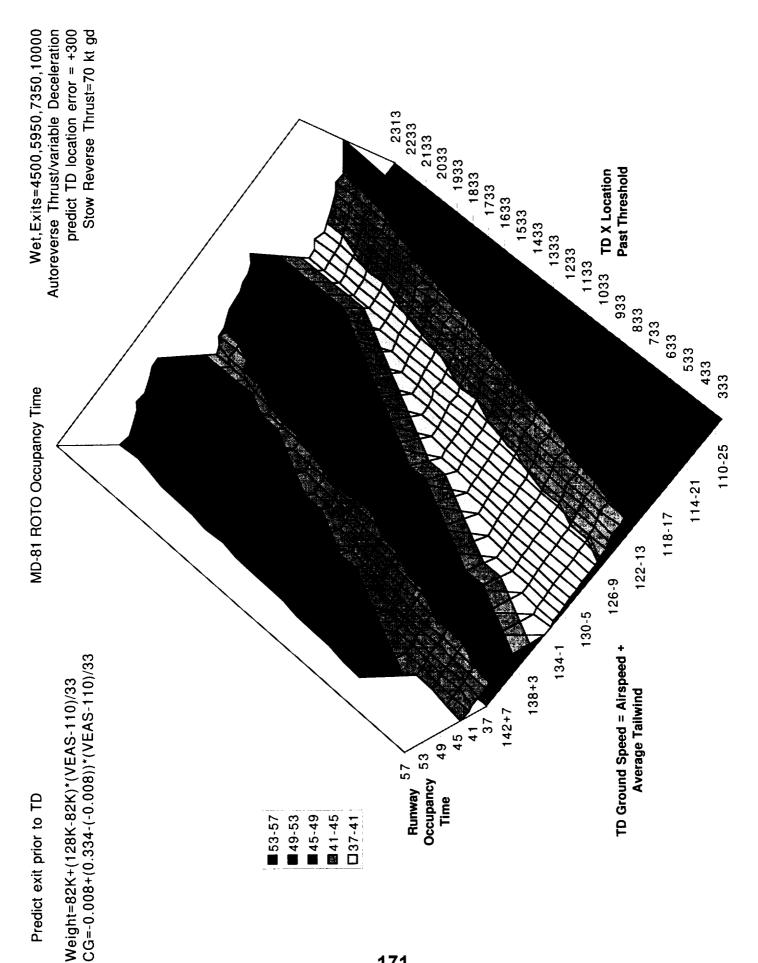


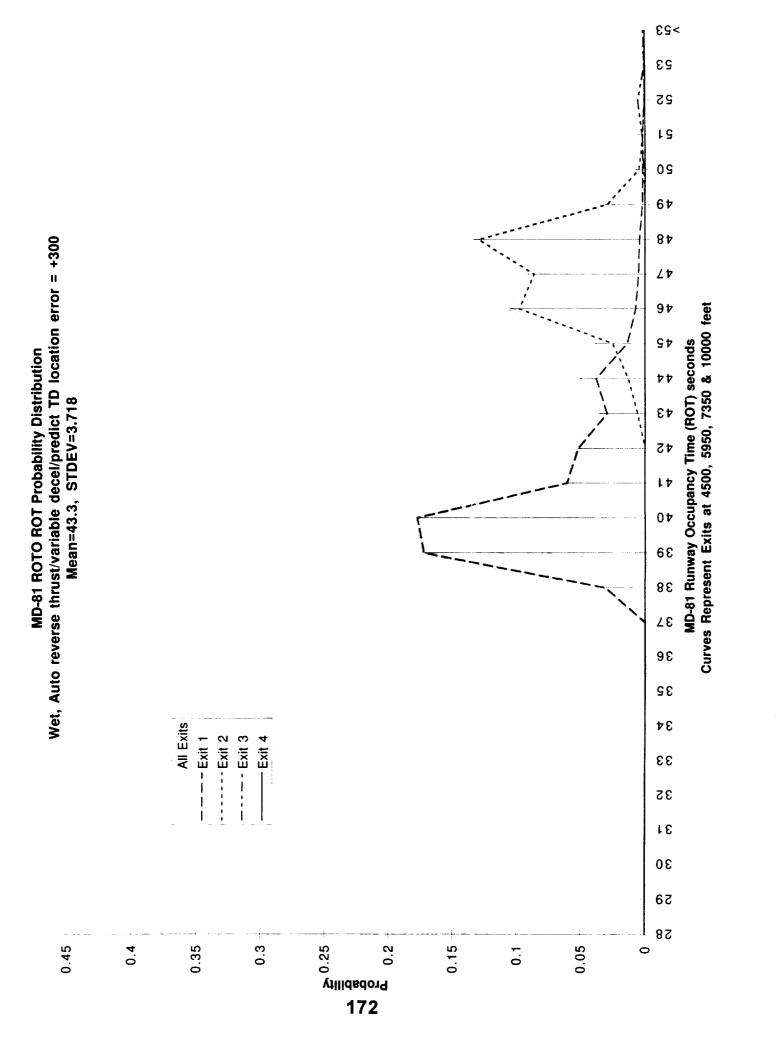


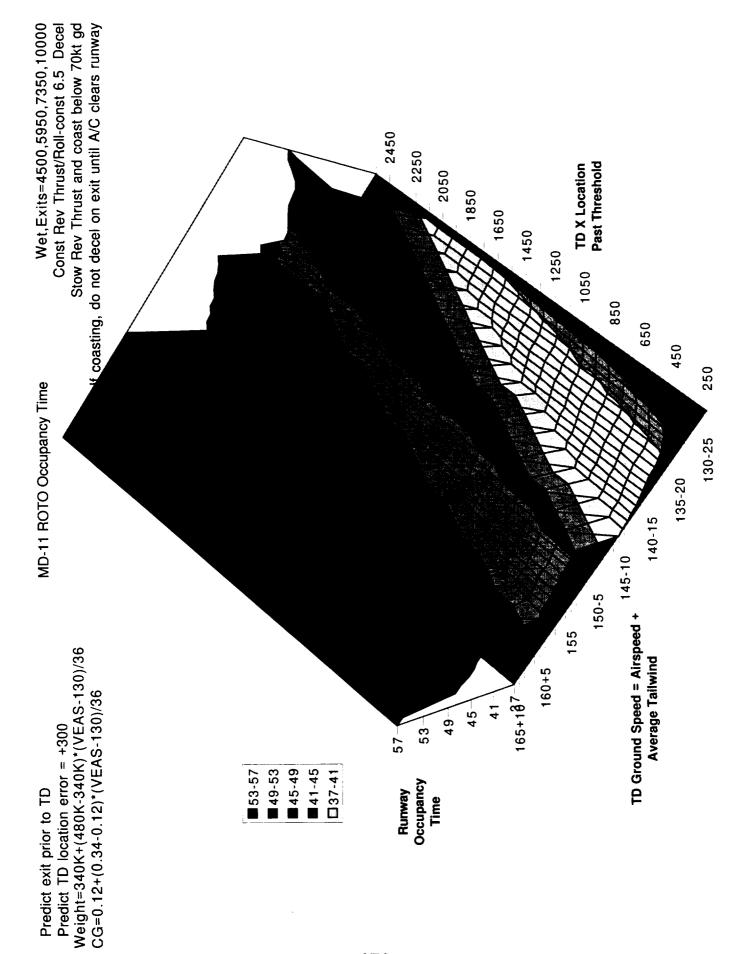


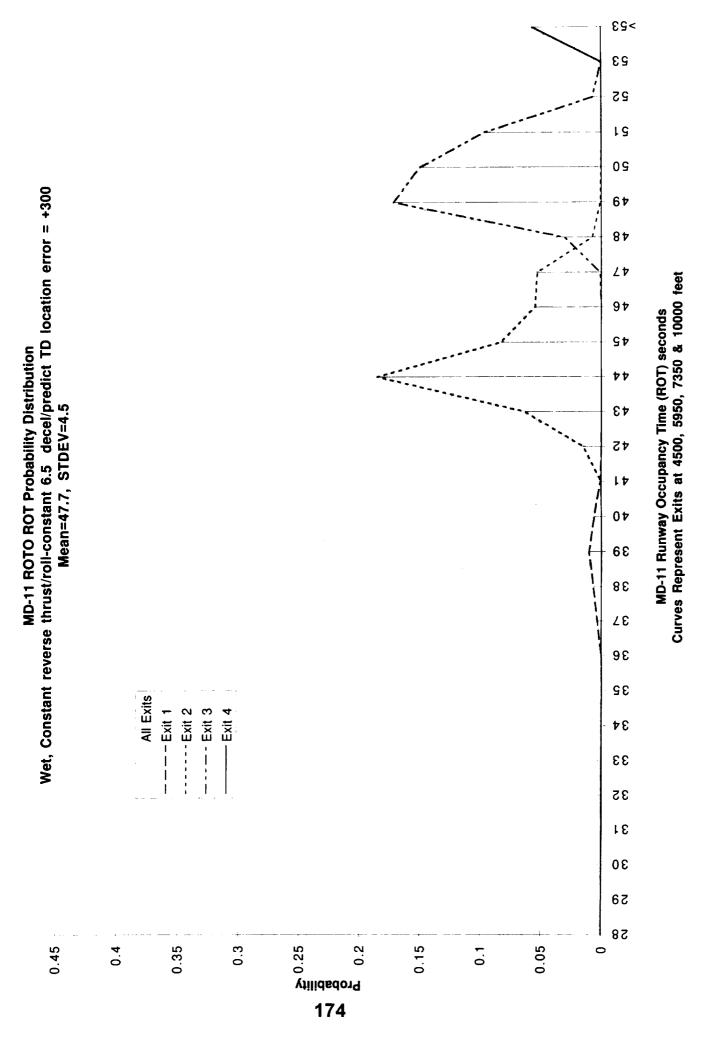
>23 63 25 19 9 6*†* 81 Wet, Auto reverse thrust/variable decel/predict TD location error = +300 ۷4 91 97 77 Mean=49.2, STDEV=4.51 £ \$ 45 01 38 88 **Δ**ε 98 All Exits 32 ----- Exit 2 ----- Exit 3 ---Exit 1 33 35 15 30 58 82 Villidedora 0.25 0.25 0.45 0.05 0.3 0.15 0 0.35 0.1 0.4 170

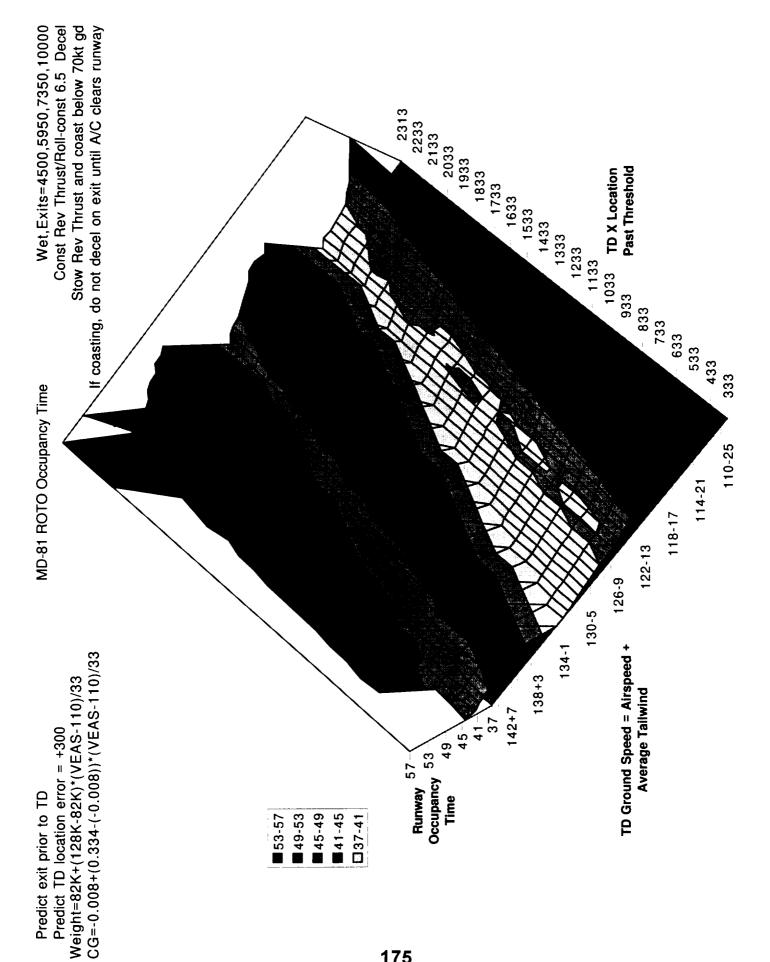
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

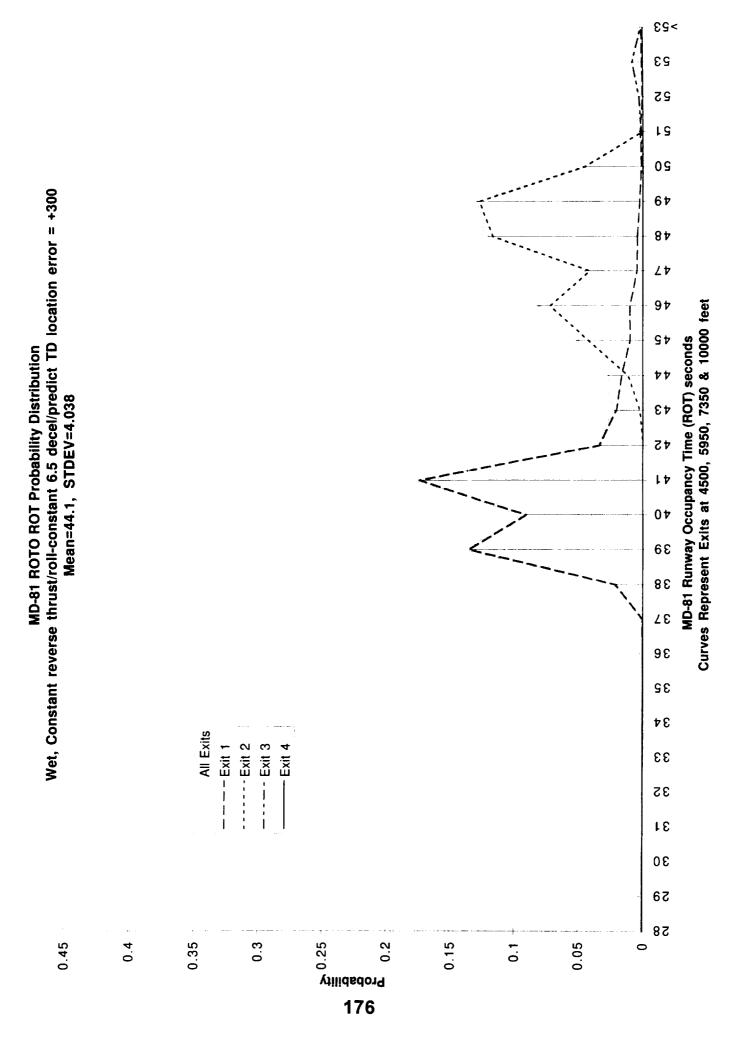


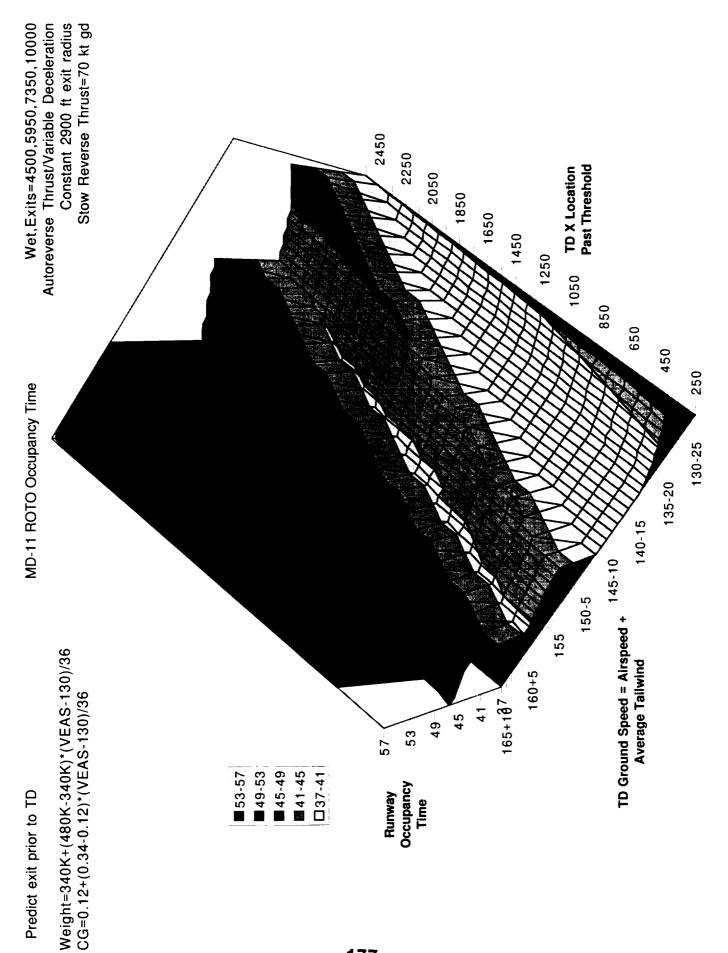






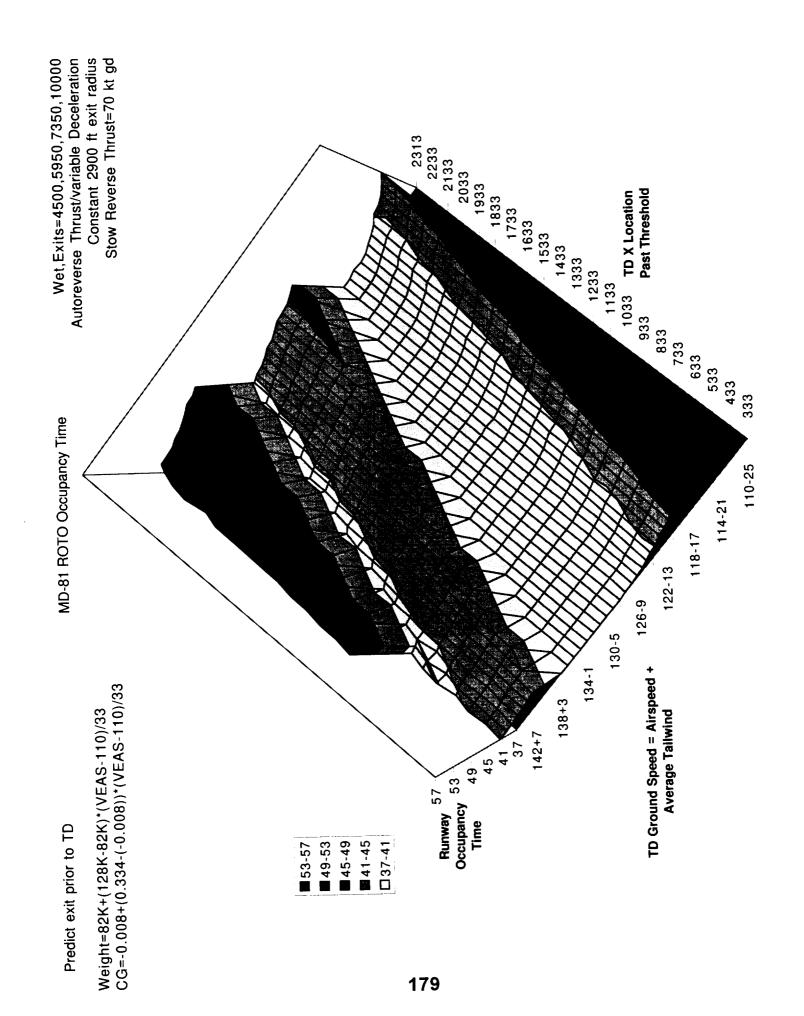


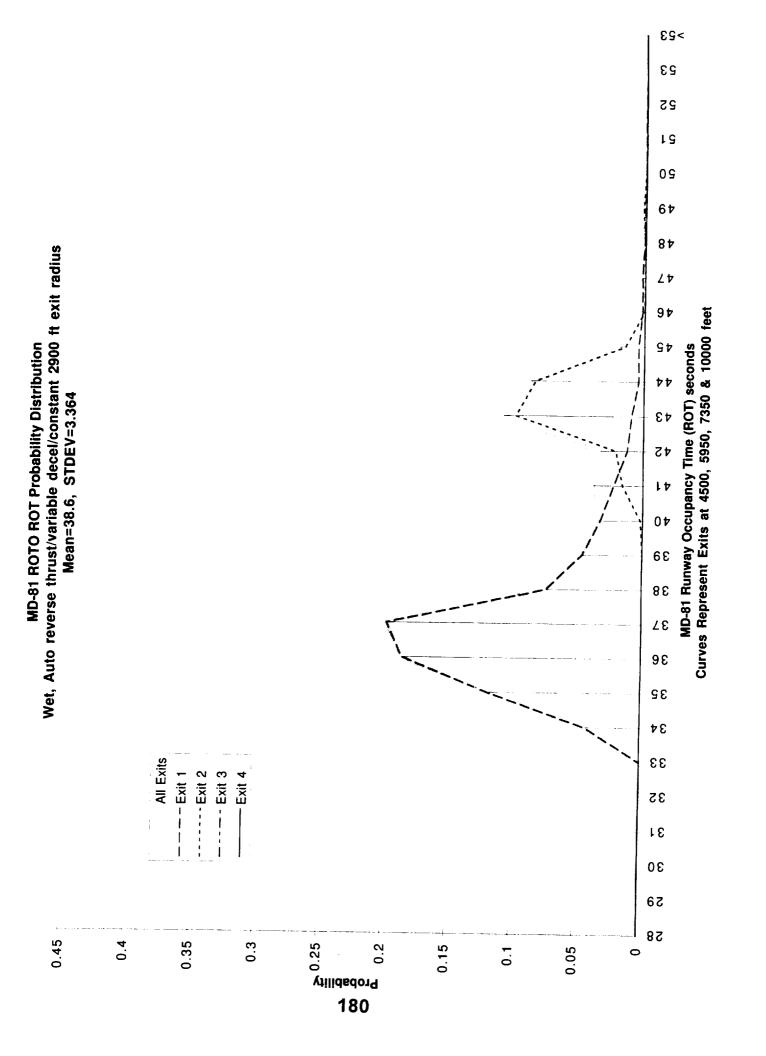


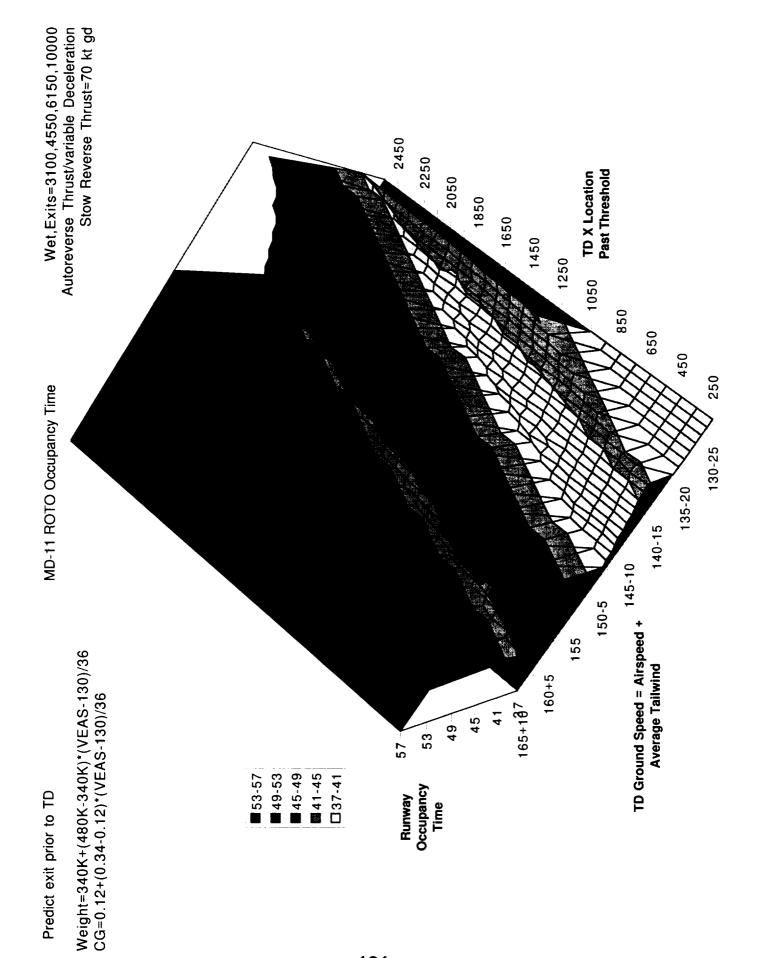


>23 *t* Wet, Auto reverse thrust/variable decel/constant 2900 ft exit radius Mean=44.0, STDEV=4.33 All Exits Exit 4 - Exit 3 ----- Exit 2 -- Exit 1 0.35 O SS O SS 0.45 0.3 0.15 0.4 0.1 0.05

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

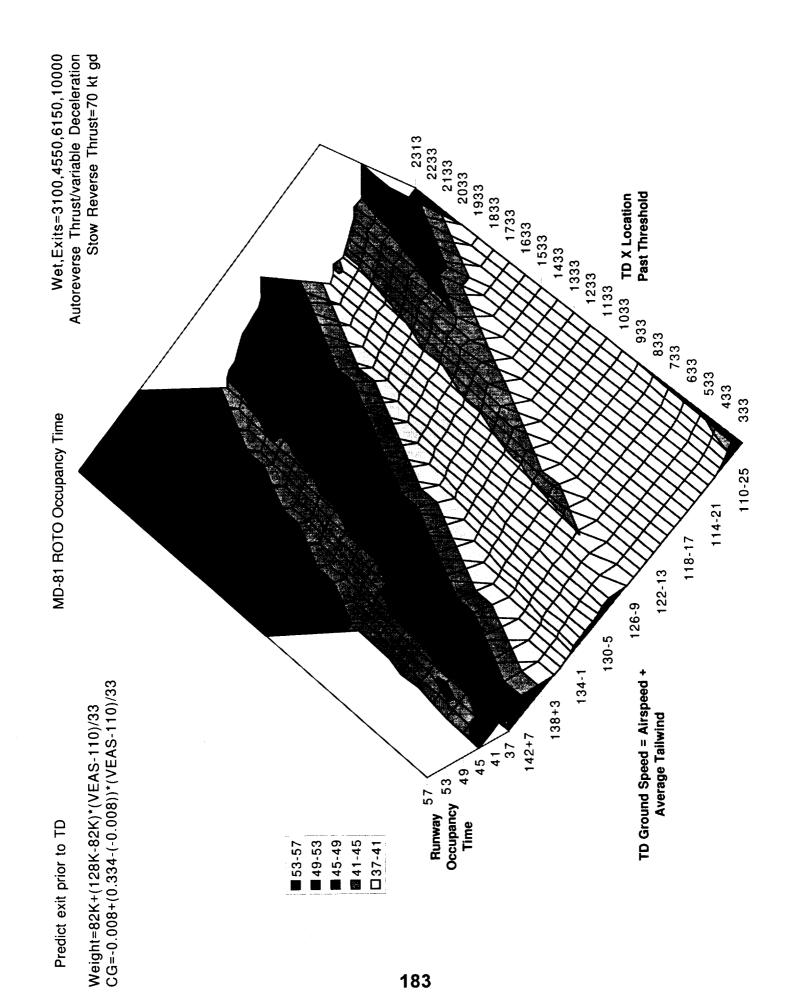




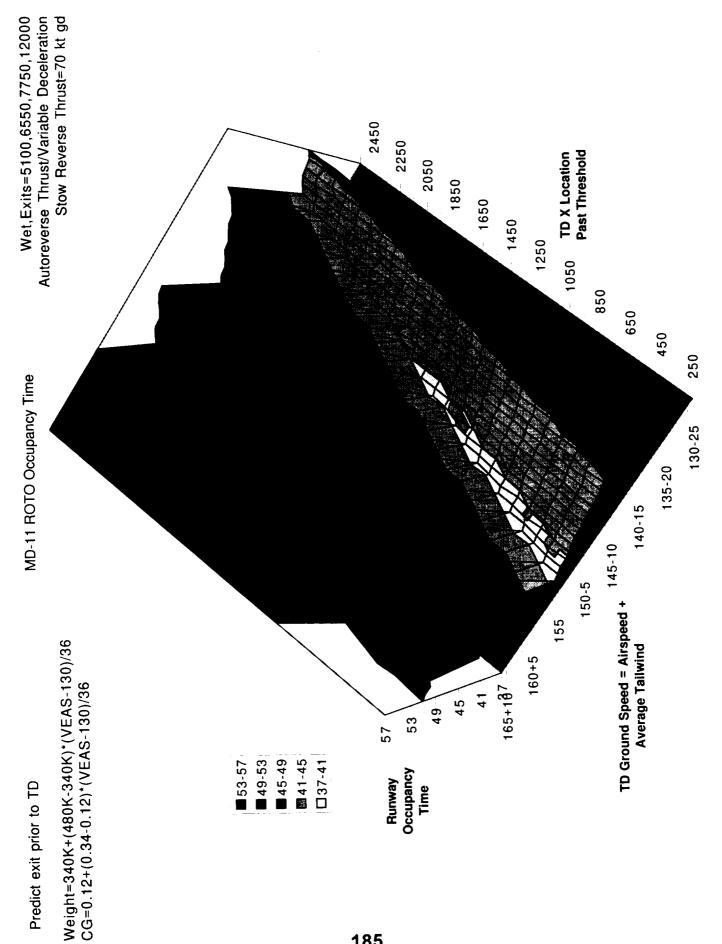


>23 23 25 19 09 6 t 81 ۷7 91 97 Wet, Auto reverse thrust/variable decel Mean=50.9, STDEV=9.05 77 £\$ 45 11 01 33 88 All Exits - Exit 4 ----- Exit 3 32 ----- Exit 2 ----Exit 1 98 32 34 33 35 15 30 58 82 Villdador9 0.05 0.15 0 0.35 0.1 0.45 0.4 0.3 182

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3100, 4550, 6150 & 10000 feet

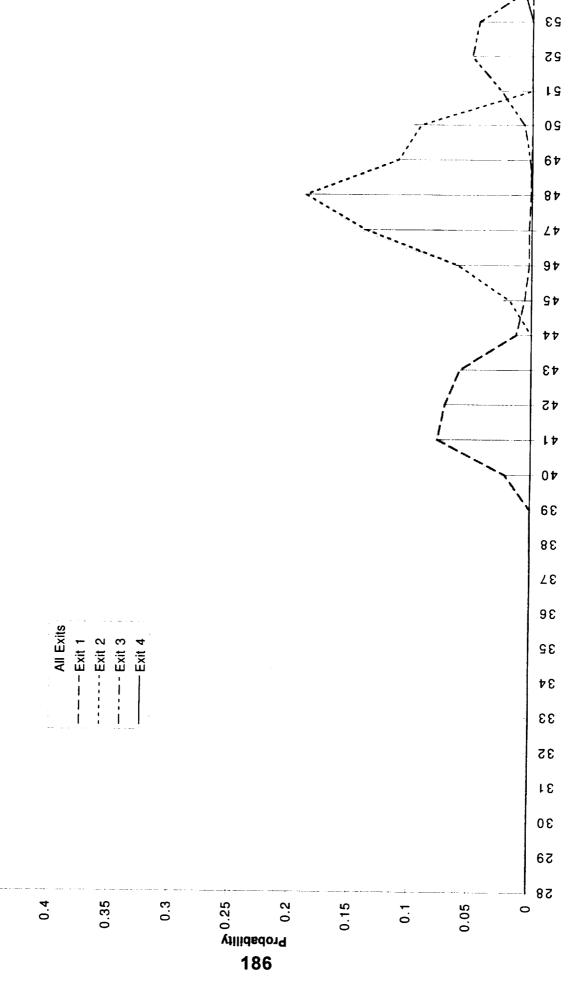


>23 23 25 19 09 6*†* 84 All Exits ----- Exit 2 **۷** ----Exit 1 Curves Represent Exits at 3100, 4550, 6150 & 10000 feet 91 MD-81 Runway Occupancy Time (ROT) seconds 97 Wet, Auto reverse thrust/variable decel Mean=41.1, STDEV=4.122 33 38 **4** E 98 32 34 33 35 18 30 58 82 Probability
0.25 **0**.4 0.35 0.3 0.15 0.05 0.45 0.2 0.1 0 184



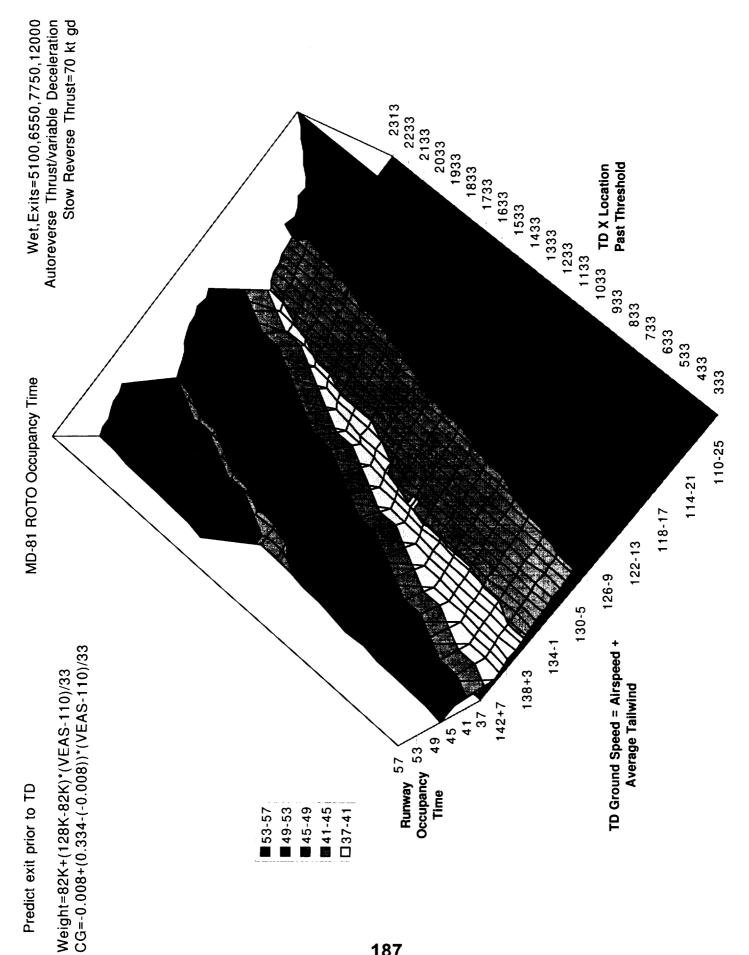
MD-11 ROTO ROT Probability Distribution Wet, Auto reverse thrust/variable decel Mean=47.1, STDEV=4.07

0.45

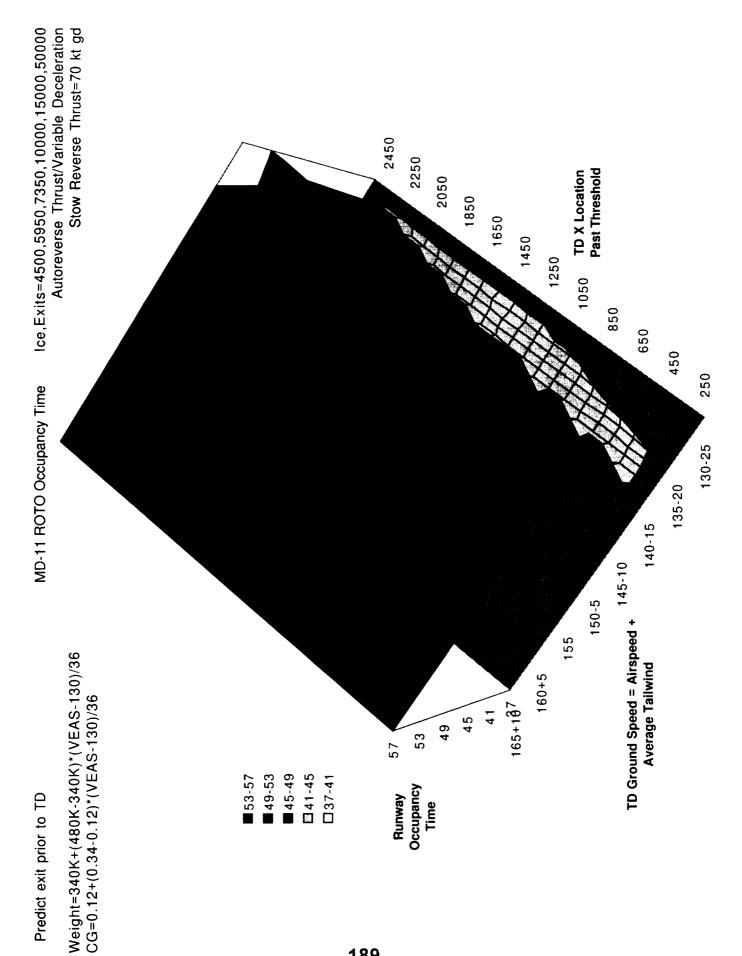


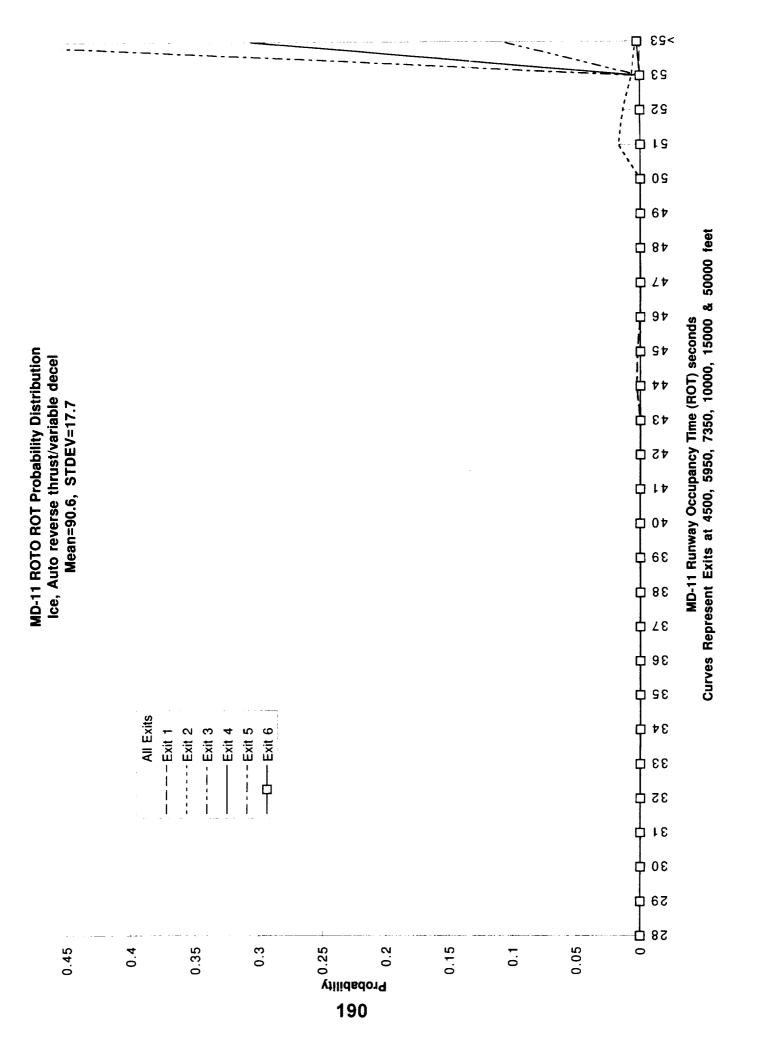
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 5100, 6550, 7750 & 12000 feet

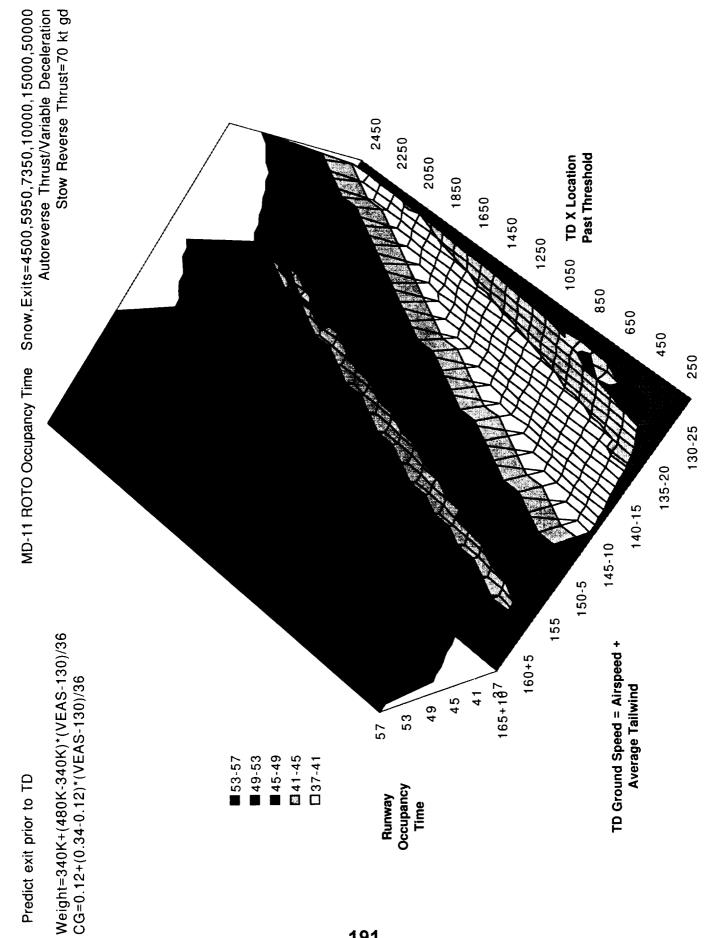
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>23 23 25 13 09 6*†* 84 ۷Þ Curves Represent Exits at 5100, 6550, 7750 & 12000 feet 9 7 97 MD-81 Runway Occupancy Time (ROT) seconds Wet, Auto reverse thrust/variable decel Mean=44.4, STDEV=3.457 £ \$ 45 0*t* 6ε 38 32 98 32 All Exits - Exit 4 ----Exit 1 ----- Exit 3 ----- Exit 2 34 33 35 18 30 58 82 Villidsdor9 0.05 0.5 0.15 0.1 0 0.45 4.0 0.35 0.3 188







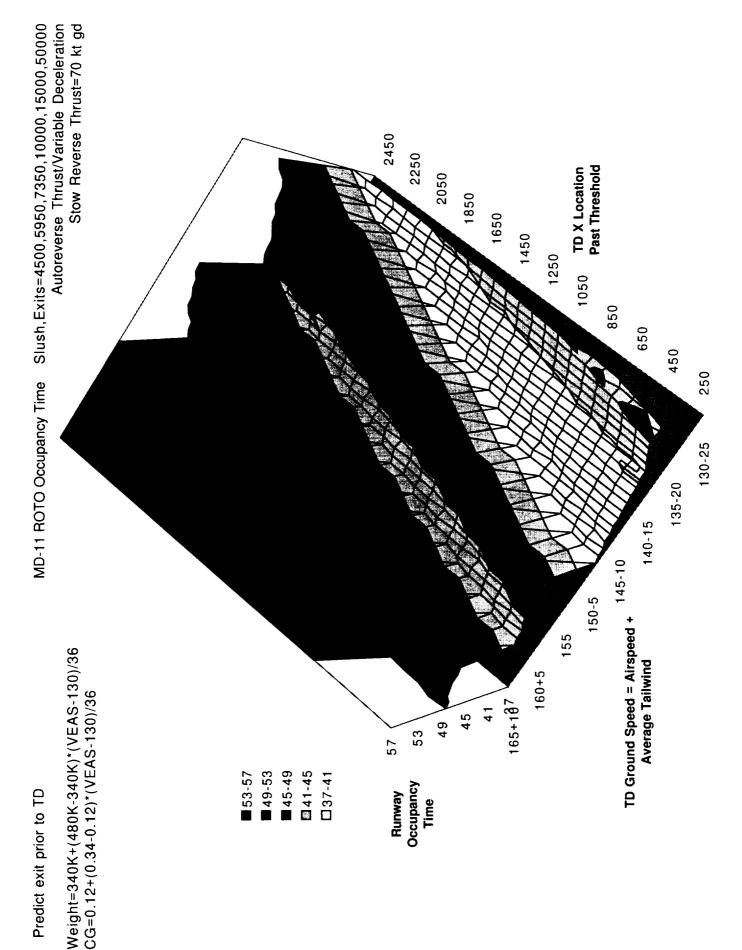
52 🗅 13 09 6*†* 81 **1** 91 Snow, Auto reverse thrust/variable decel Mean=48.5, STDEV=5.15 97 **MD-11 ROTO ROT Probability Distribution** £ 7 45 01 38 8£ 48 98 All Exits 32 - Exit 4 ----- Exit 5 ____Exit 6 ----- Exit 2 ----- Exit 3 ----Exit 1 34 33 35 🗅 31 🗅 30 🗅 58 。 早 8 S Villidsdor9 0.45 0.4 0.35 0.3 0.2 0.15 0.1 0.05

192

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350, 10000, 15000 & 50000 feet

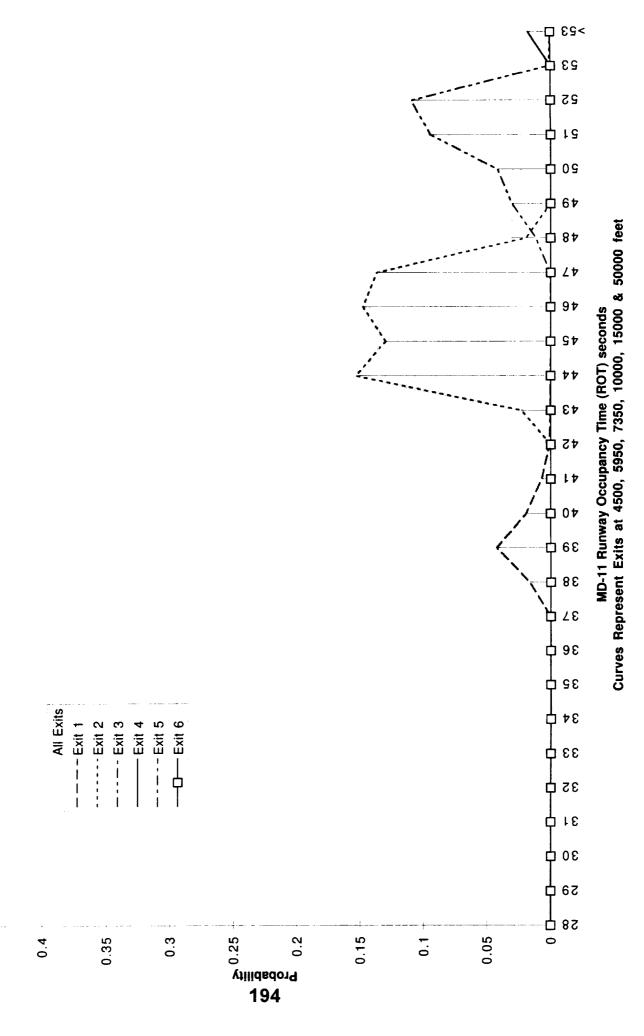
₽ 29 🖵

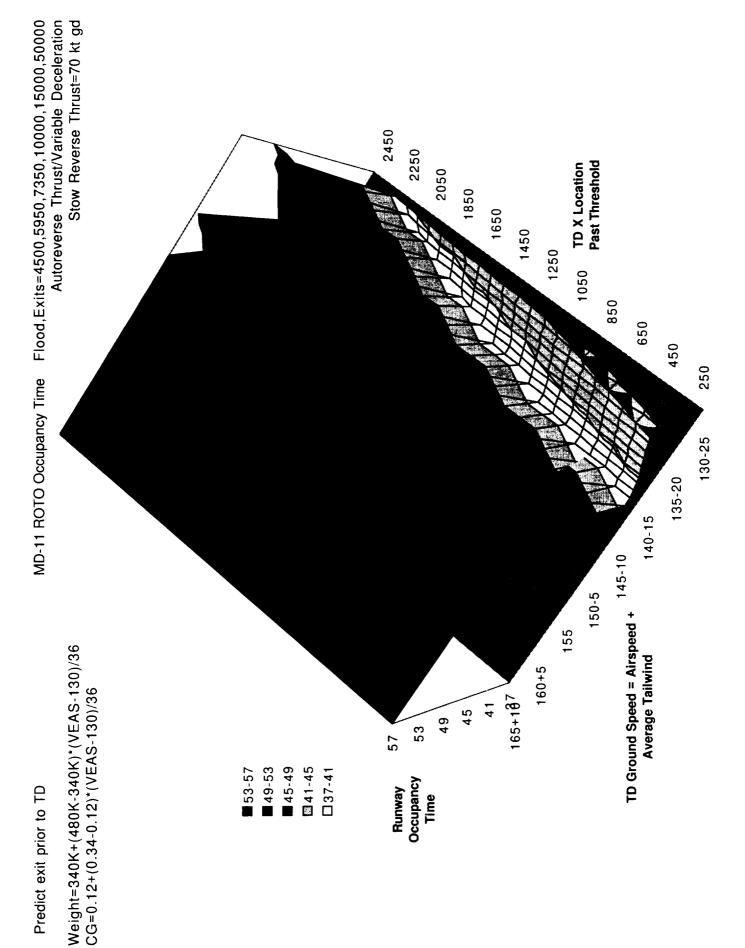
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MD-11 ROTO ROT Probability Distribution Slush, Auto reverse thrust/variable decel Mean=46.7, STDEV=4.06

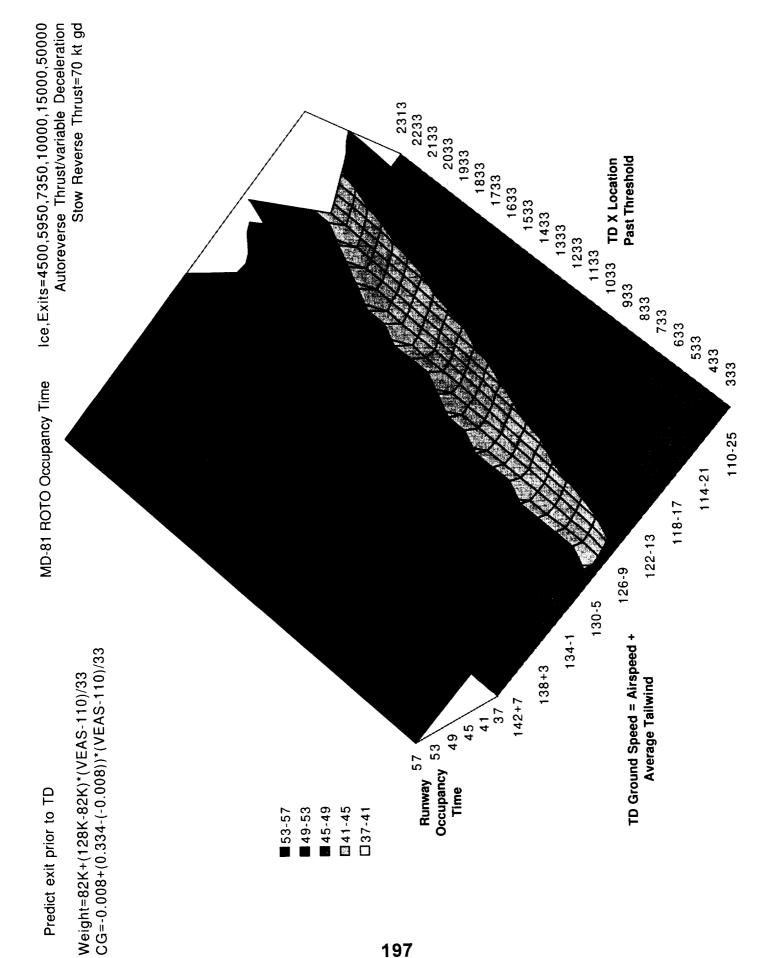
0.45





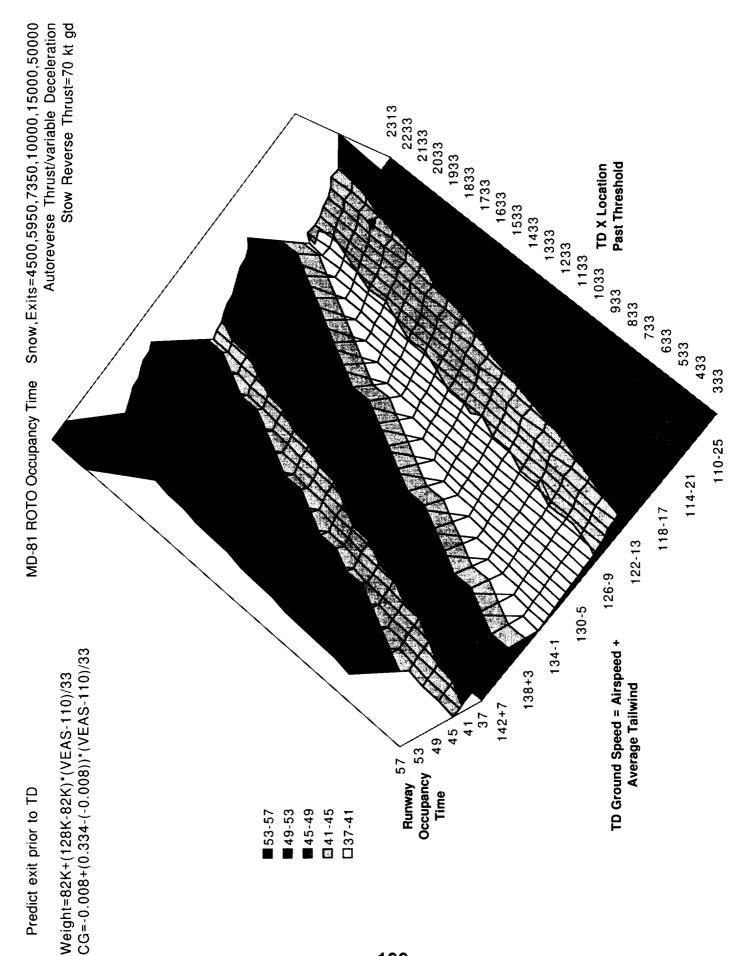
₽ 89< 63 25 19 09 **☆** 6⊅ ₽ 8 ₽ ۷Þ 91 91 Flood, Auto reverse thrust/variable decel Mean=71.1, STDEV=19.8 €\$ 45 1 1 1中 01 <u>†</u> 6ε 8£ ٤٤ 98 32 34 🗅 All Exits - Exit 4 - Exit 5 ———Exit 6 - Exit 1 - Exit 3 --- Exit 2 33 🖒 35 🗅 31 🗅 30 🗅 **₽** 62 о Р 85 Villidsdor9 0.5 0.05 0.15 0.3 0.1 0.45 0.4 0.35 196

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350, 10000, 15000 & 50000 feet

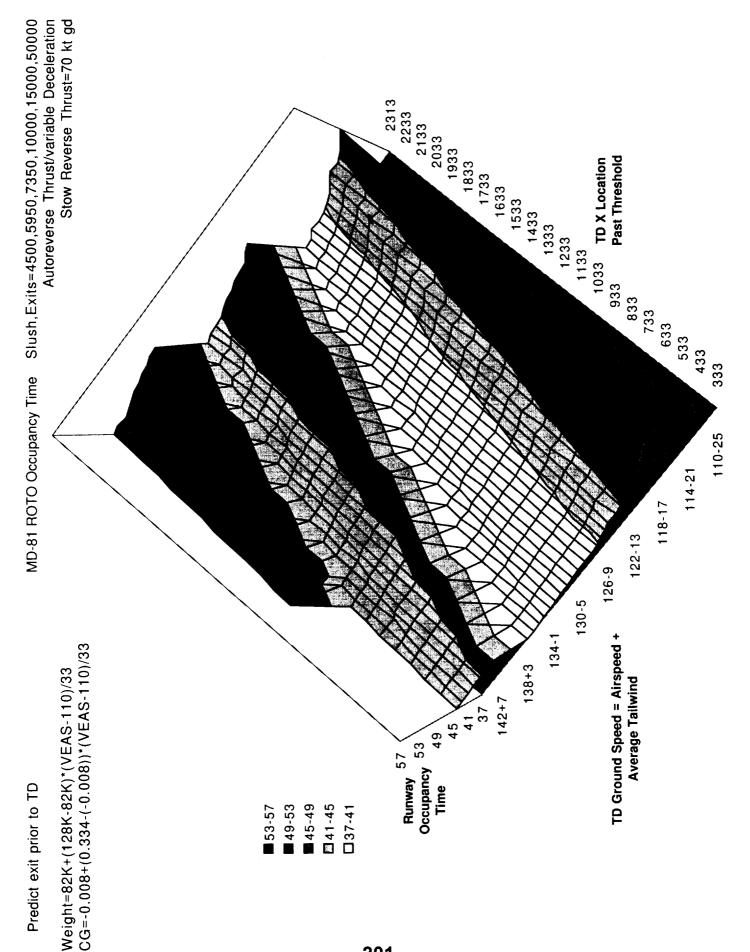


53 25 19 09 6*†* 1中 84 Curves Represent Exits at 4500, 5950, 7350, 10000, 15000 & 50000 feet ሷ ∠ቱ 91 MD-81 ROTO ROT Probability Distribution Ice, Auto reverse thrust/variable decel Mean=54.4, STDEV=13.24 36 🛱 35 🖒 **7** € All Exits 33 🖒 Exit 4 ____Exit 6 ---Exit 1 ----- Exit 2 -- Exit 3 ---- Exit 5 32 🖒 31 🗅 30 🗅 58 о 1985 Probability 0.25 0.45 0.4 0.35 0.3 0.2 0.15 0.05 0.1 198

₽ 89<



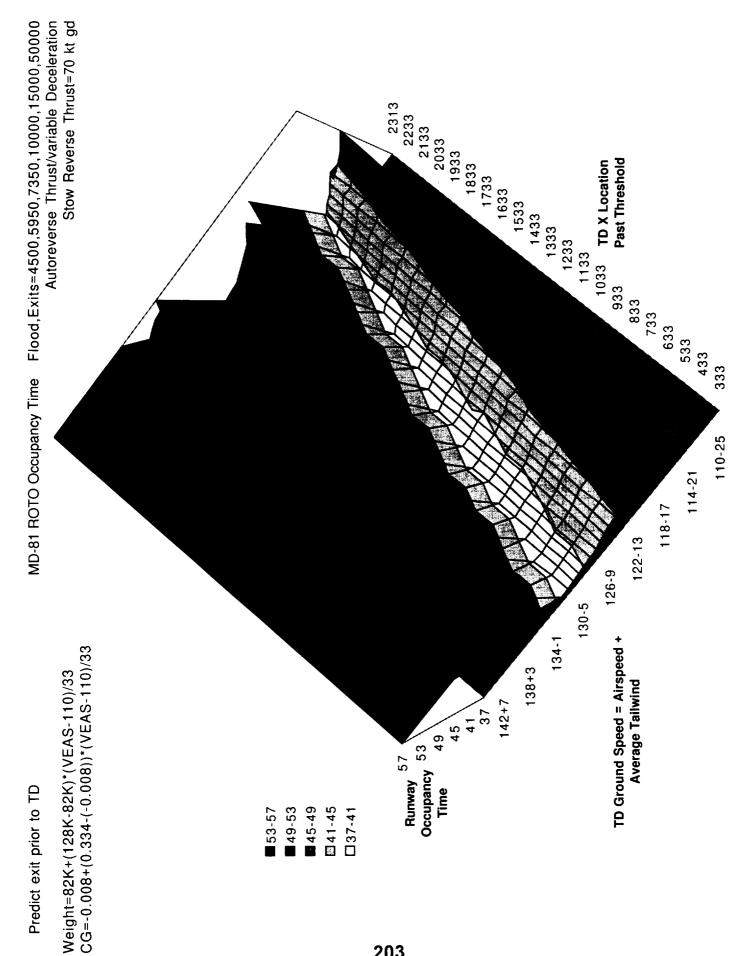
₽ 89< 23 25 19 09 6*†* 81 Curves Represent Exits at 4500, 5950, 7350, 10000, 15000 & 50000 feet ۷*۲* **□** 9 • 7 8 9 0 1 2 3 4 5 MD-81 Runway Occupancy Time (ROT) seconds MD-81 ROTO ROT Probability Distribution Snow, Auto reverse thrust/variable decel Mean=42.6, STDEV=3.533 98 32 34 🗅 All Exits -- Exit 3 Exit 4 - Exit 5 ----- Exit 2 33 🖒 ---Exit 1 32 🖒 31 🛱 30 🛱 **☆** 67 о 9 8 9 700 villidedora 0.15 0.45 **0**.4 0.35 0.3 0.1 0.05



₽ 89< **₽** €9 **2**5 🖒 19 09 67 84 Curves Represent Exits at 4500, 5950, 7350, 10000, 15000 & 50000 feet L Þ 91 97 MD-81 Runway Occupancy Time (ROT) seconds **中**07 **φ** 6ε **φ** 8ε 98 35 34 All Exits Exit 4 ----Exit 1 ----- Exit 2 -- Exit 5 Exit 6 33 🗅 ---- Exit 3 35 🖒 31 🛱 30 🛱 **口 62** о Ч 85 Probability 0.25 0.15 0.05 0.35 0.3 0.1 4.0 202

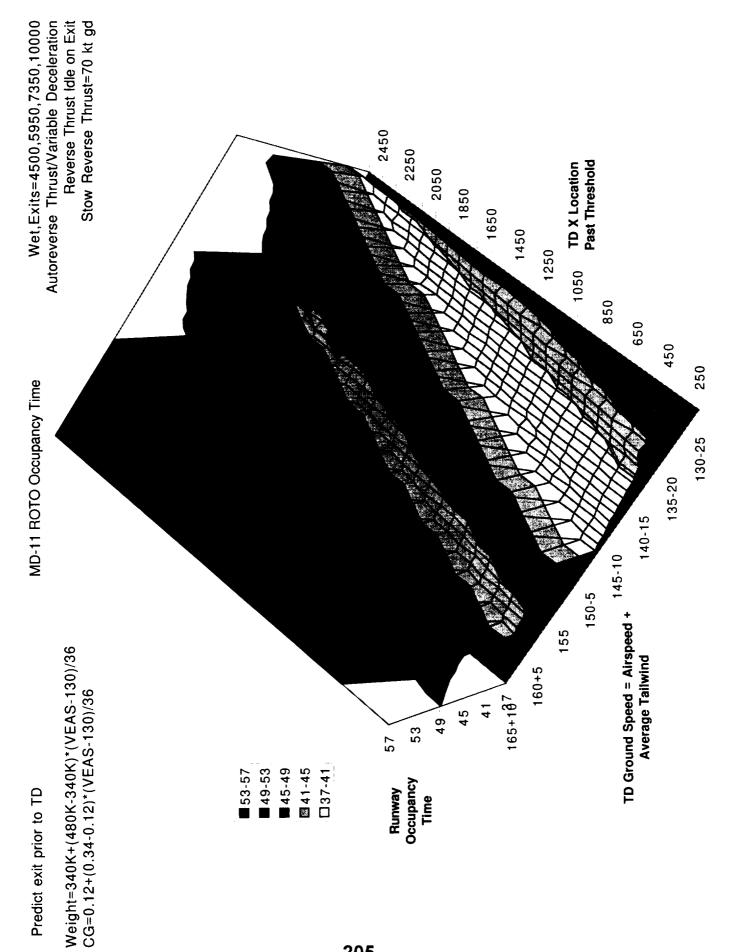
MD-81 ROTO ROT Probability Distribution Slush, Auto reverse thrust/variable decel Mean=41.3, STDEV=3.149

0.45



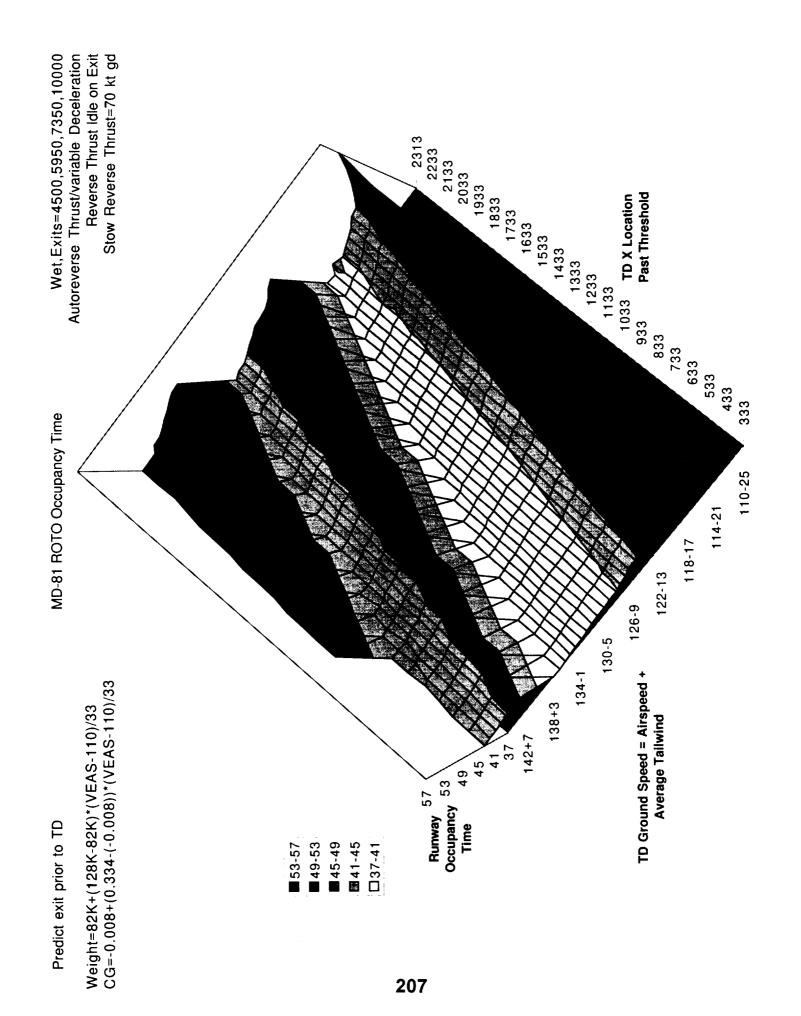
23 2S 🖒 19 09 6₺ 84 Curves Represent Exits at 4500, 5950, 7350, 10000, 15000 & 50000 feet 91 MD-81 ROTO ROT Probability Distribution Flood, Auto reverse thrust/variable decel Mean=46.7, STDEV=5.939 **₽** 0₽ **φ** 6ε 36 🛱 35 🖒 34 All Exits ---Exit 1 - Exit 4 ----- Exit 5 Exit 6 33 ---- Exit 3 ----- Exit 2 32 🖒 31 🖒 30 🛱 58 о Р 82 Sillidedorq Villidedorq 504 0.45 0.15 0.05 0.3 0.35 0.1 0.4

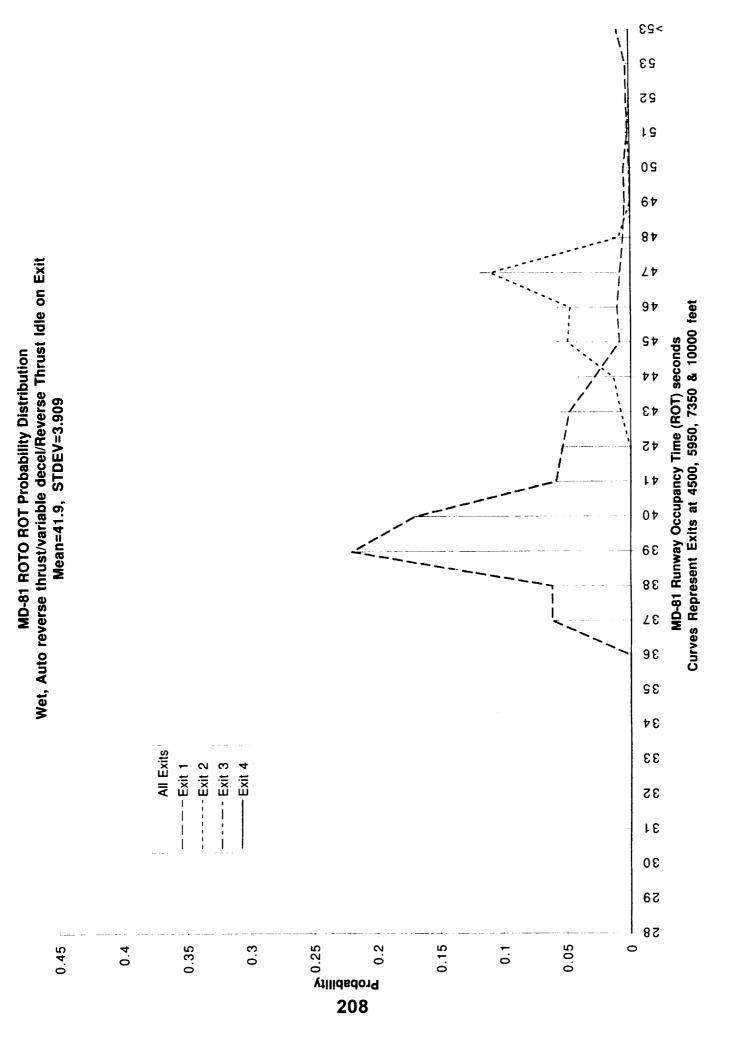
₽ 89<

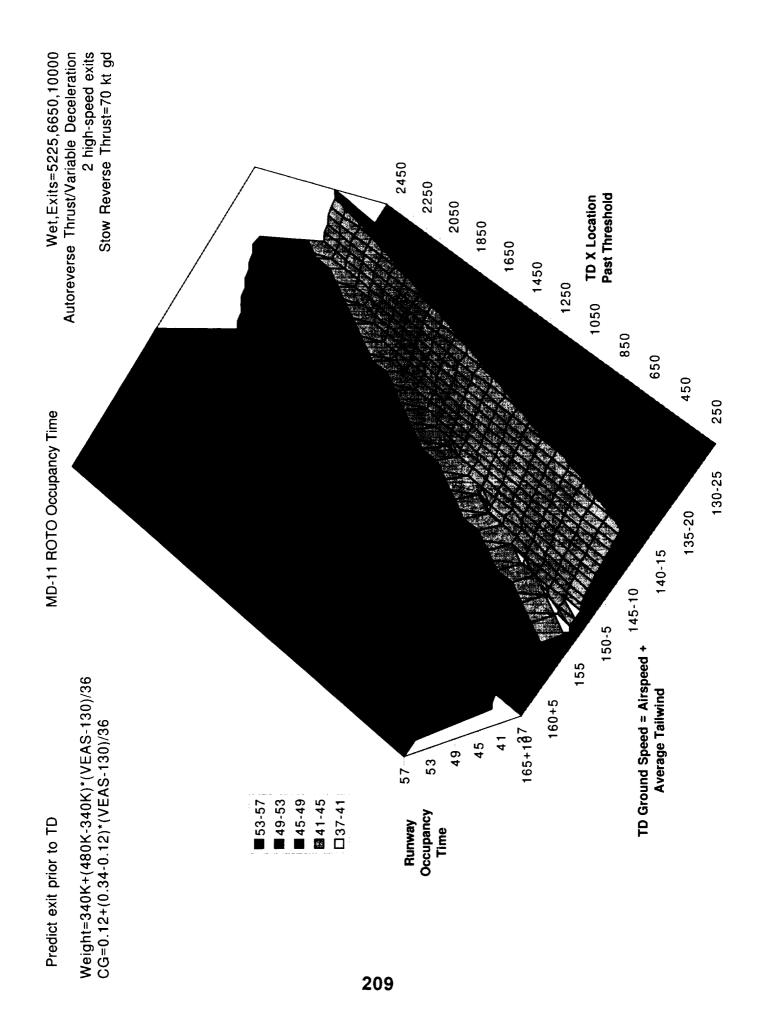


>23 23 25 13 09 6 Þ 81 Wet, Auto reverse thrust/variable decel/Reverse Thrust Idle on Exit Mean=47.3, STDEV=4.2 10 91 97 **†** † **t**3 45 14 01 38 38 37 98 32 All Exits .- Exit 3 - Exit 4 ----Exit 1 ----- Exit 2 34 33 35 15 30 58 82 506 Villidadorq 0.35 0.3 0.45 0.05 4.0 0.1 0

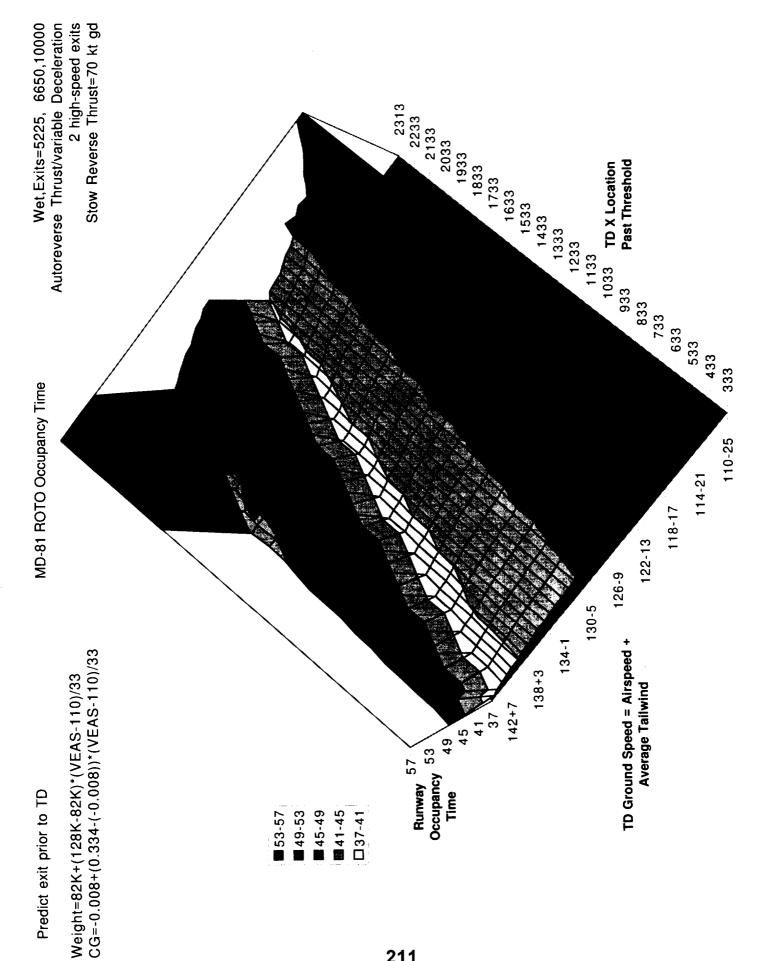
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet







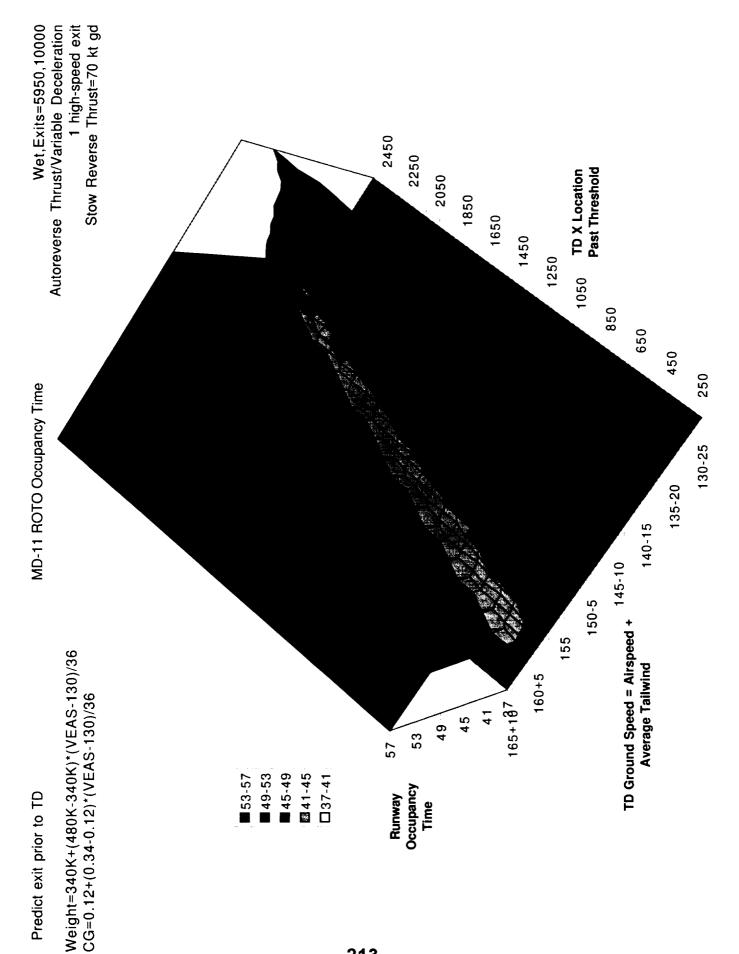
>23 23 25 19 09 6*†* 8₽ ۷ ل Wet, Auto reverse thrust/variable decel/2 high-speed exits Mean=48.4, STDEV=6.38 MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 5225, 6650 & 10000 feet 91 97 45 01 38 88 32 98 All Exits . - Exit 1 ----- Exit 2 -- Exit 3 32 **7 T** 33 35 15 30 58 82 210 Villidedora 0.05 0.3 0.15 0 4.0 0.35 0.1 0.45

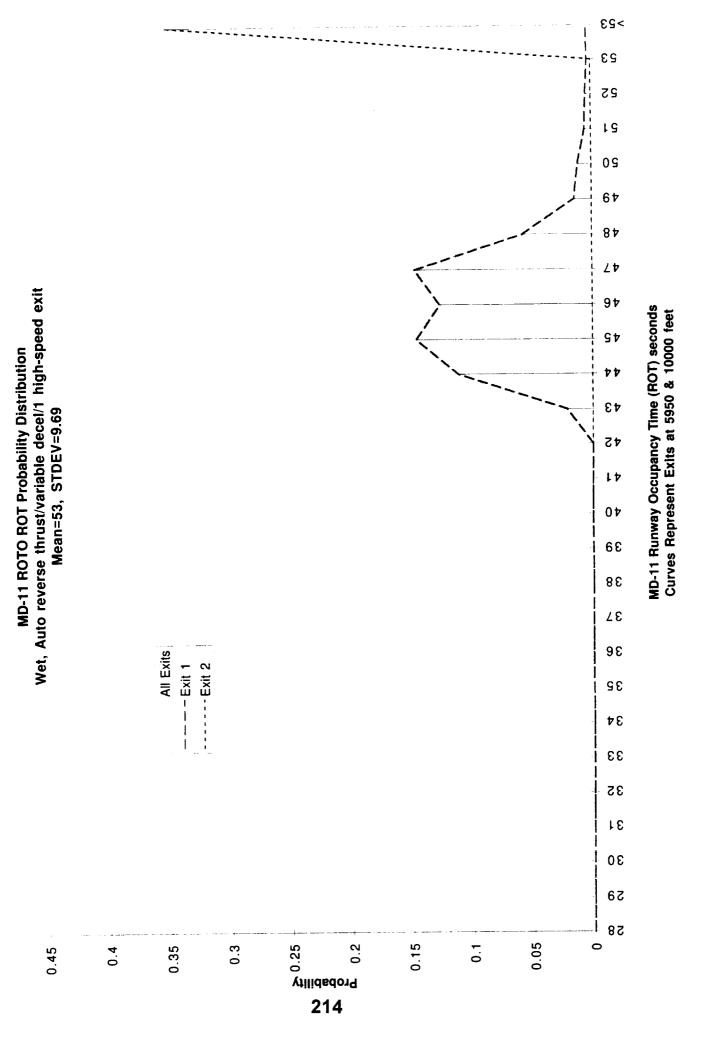


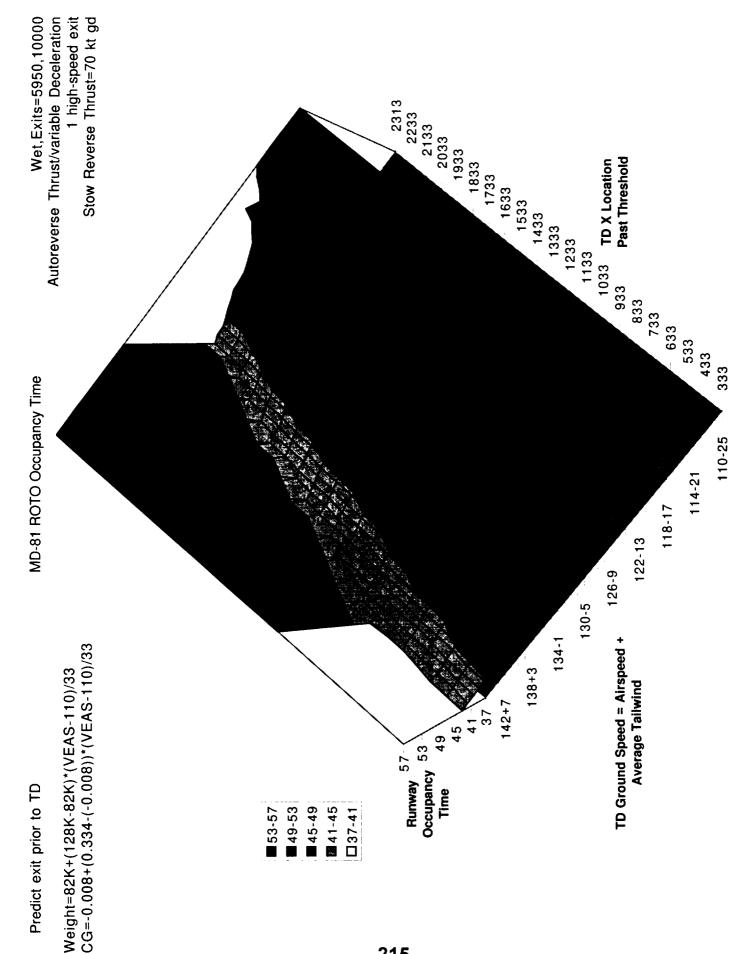
23 25 19 09 6 t 81 ۷Þ Wet, Auto reverse thrust/variable decel/2 high-speed exits Mean=45.1, STDEV=3.555 91 97 MD-81 Runway Occupancy Time (ROT) seconds **E t** 45 17 36 98 All Exits ----Exit 1 ----- Exit 2 ---- Exit 3 32 34 $\epsilon\epsilon$ 35 18 30 58 82 Villidadory 0.25 0.45 0.3 0.15 0.05 0.4 0.35 0.1 0 212

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Curves Represent Exits at 5225, 6650 & 10000 feet







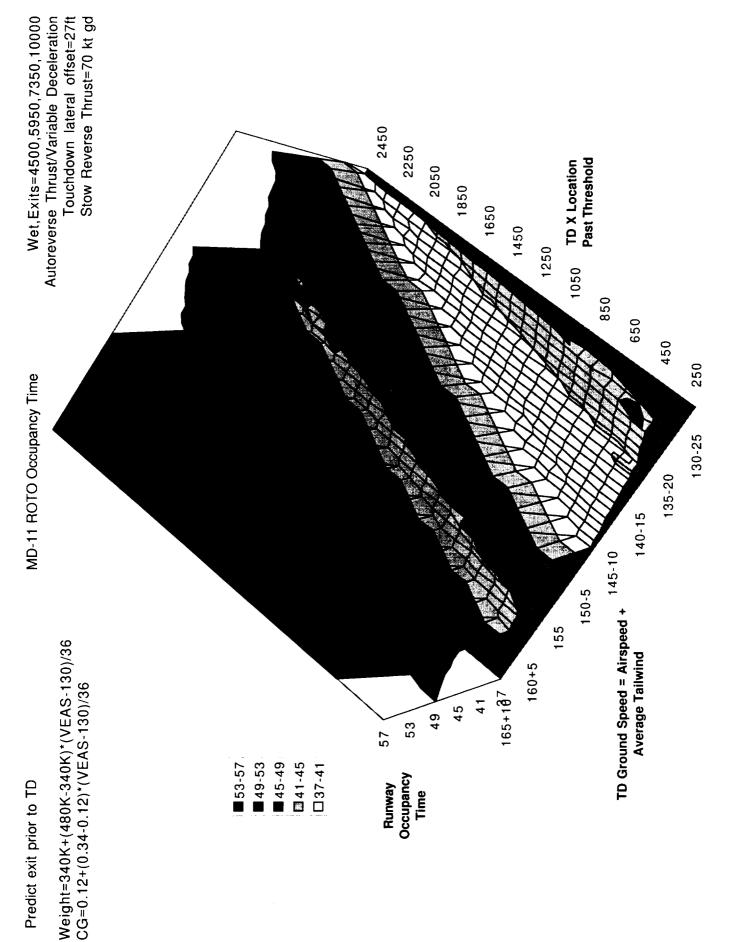
25 15 All Exits ----- Exit 3 ---- Exit 5 ----- Exit 2 - Exit 4 ----Exit 1 09 6⊅ 81 Wet, Auto reverse thrust/variable decel/4th exit location at 8300 **1** 91 91 MD-81 Runway Occupancy Time (ROT) seconds MD-81 ROTO ROT Probability Distribution Mean=41.1, STDEV=3.893 01 88 ٤٤ 98 32 **₹** 33 35 18 30 58 82 Villidsdorq 0.25 0.05 0 0.3 0.2 0.15 0.45 0.35 0.1 0.4

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Curves Represent Exits at 3900, 5350, 6950, 8300 & 10000 feet

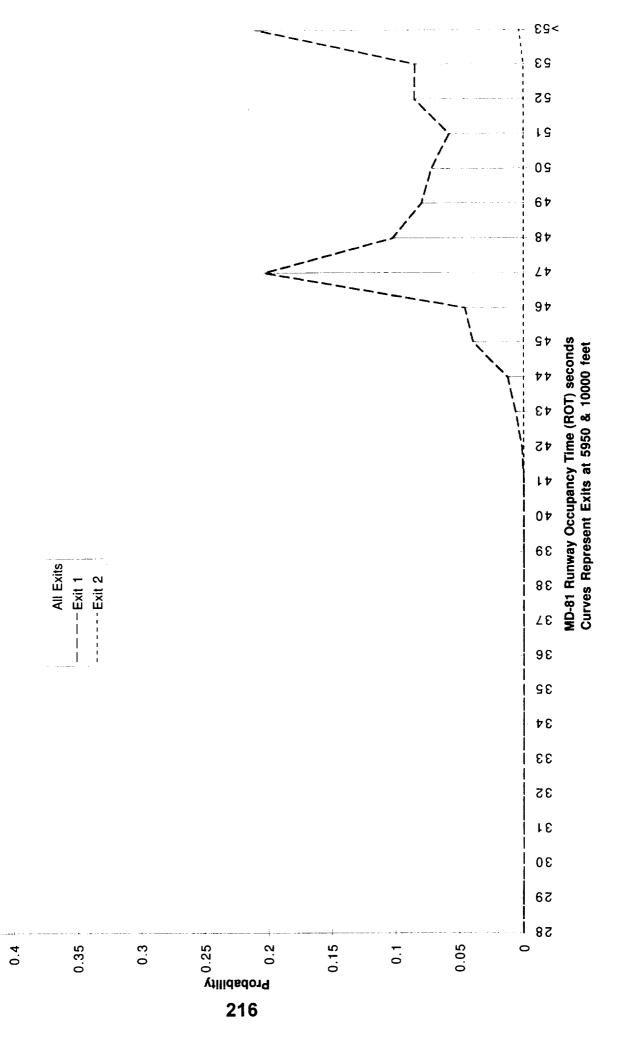


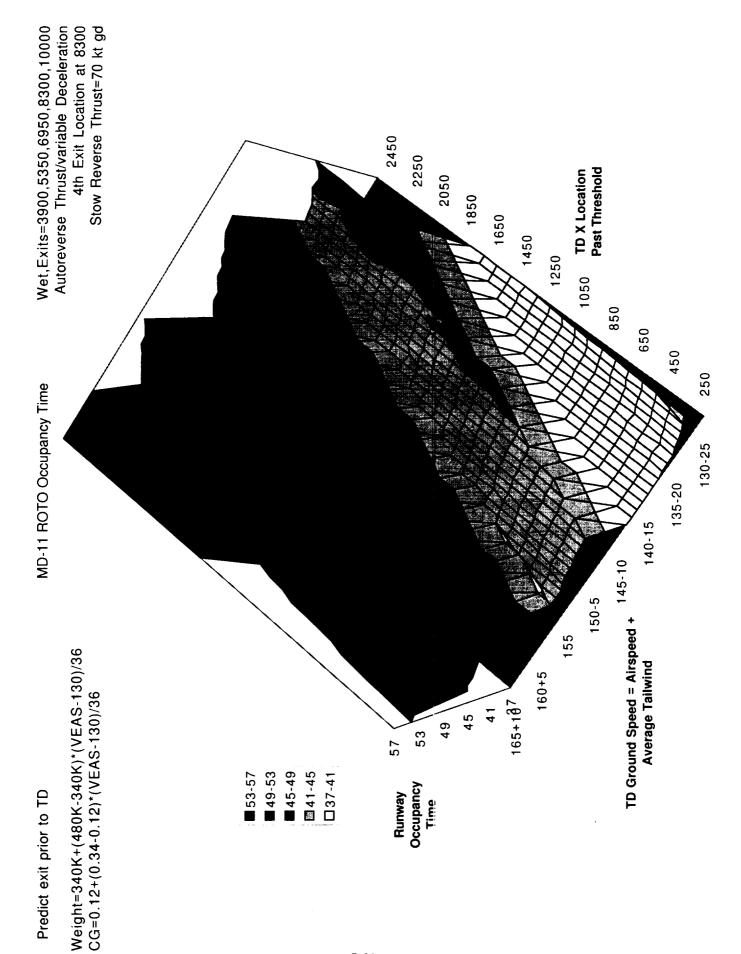
>23 23 25 13 90 6 Þ 81 L 7 Wet, Auto reverse thrust/variable decel/td lateral offset=27ft Mean=47.3, STDEV=4.21 91 97 t t 43 45 17 0*t* 38 8 E 45 98 32 All Exits · Exit 4 -- Exit 3 ----- Exit 2 ----Exit 1 34 33 35 15 30 58 82 527 Villidadora 25. 25 0.15 0.05 0 0.35 0.3 0.1 0.45 0.4

MD-11 ROTO ROT Probability Distribution

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

0.45





25 09 6*†* 81 Wet, Auto reverse thrust/variable decel/4th exit location at 8300 97 MU-11 HOIO HO! Probability DISTRIBUTION Mean=47.6, STDEV=3.97 38 88 98 All Exits Exit 4 - Exit 3 ----- Exit 2 ---Exit 1 35 82 Probability 0.25 0.45 0.35 0.3 0.5 0.15 0.05 0.4 0.1 0 218

Curves Represent Exits at 3900, 5350, 6950, 8300 & 10000 feet MD-11 Runway Occupancy Time (ROT) seconds

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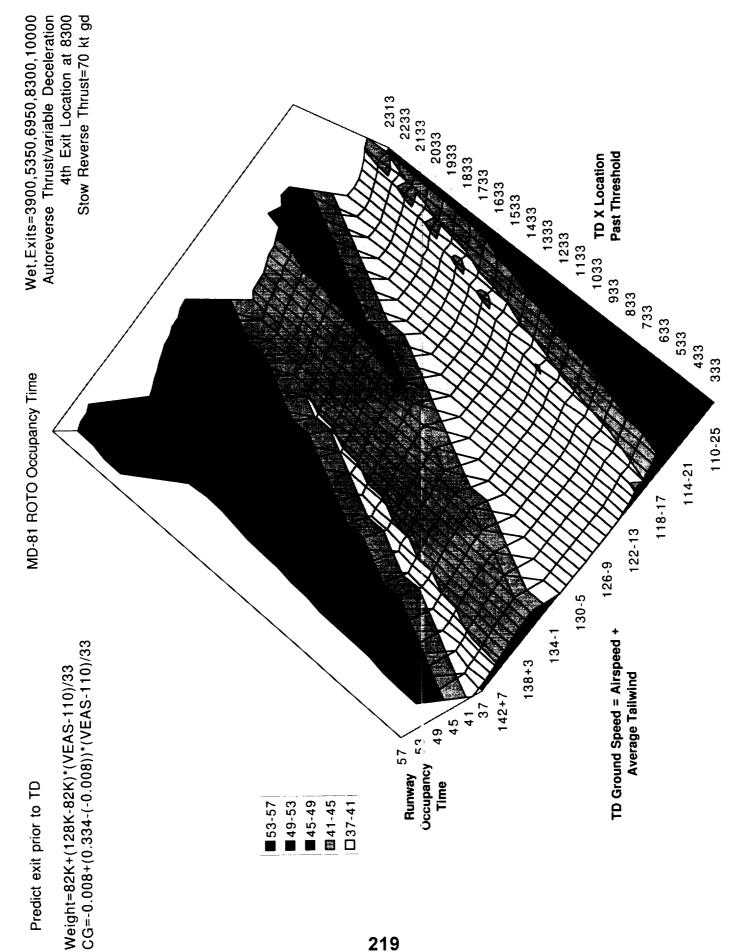
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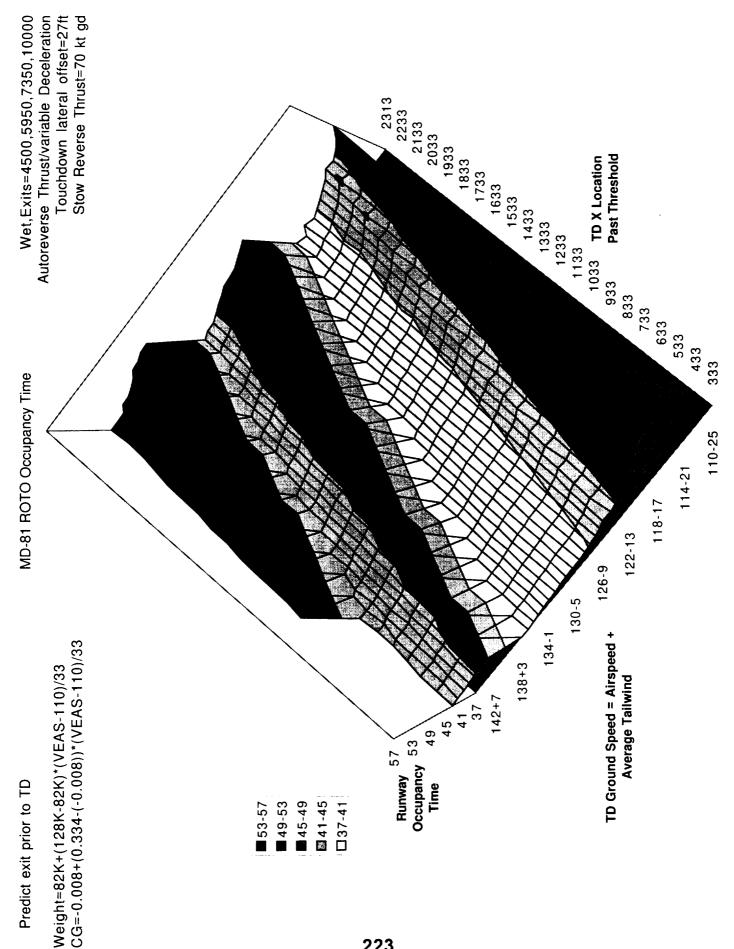
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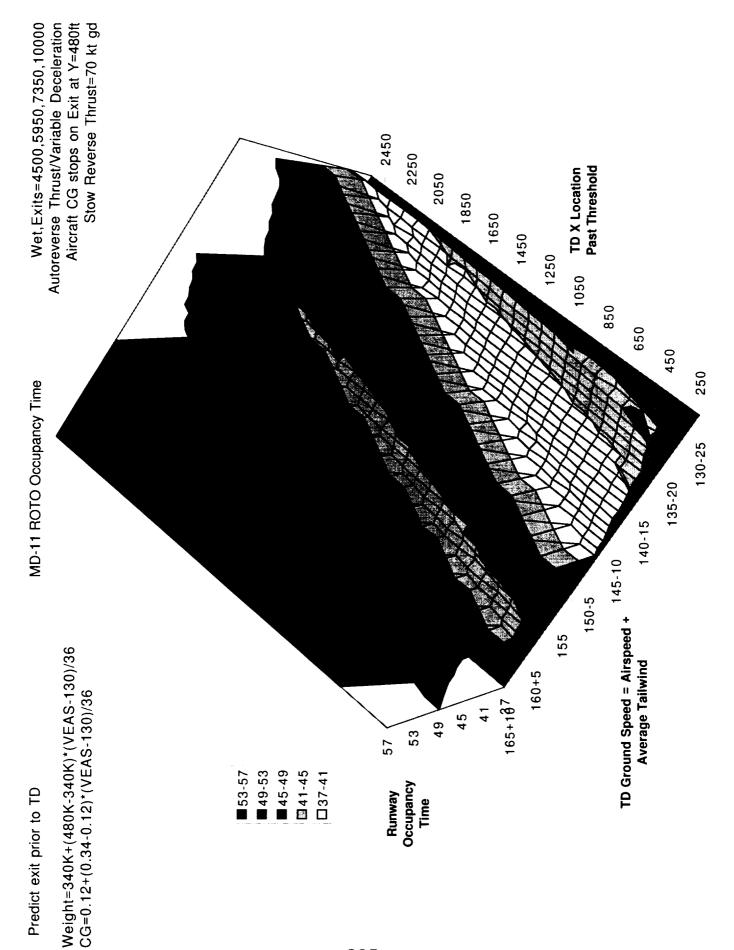


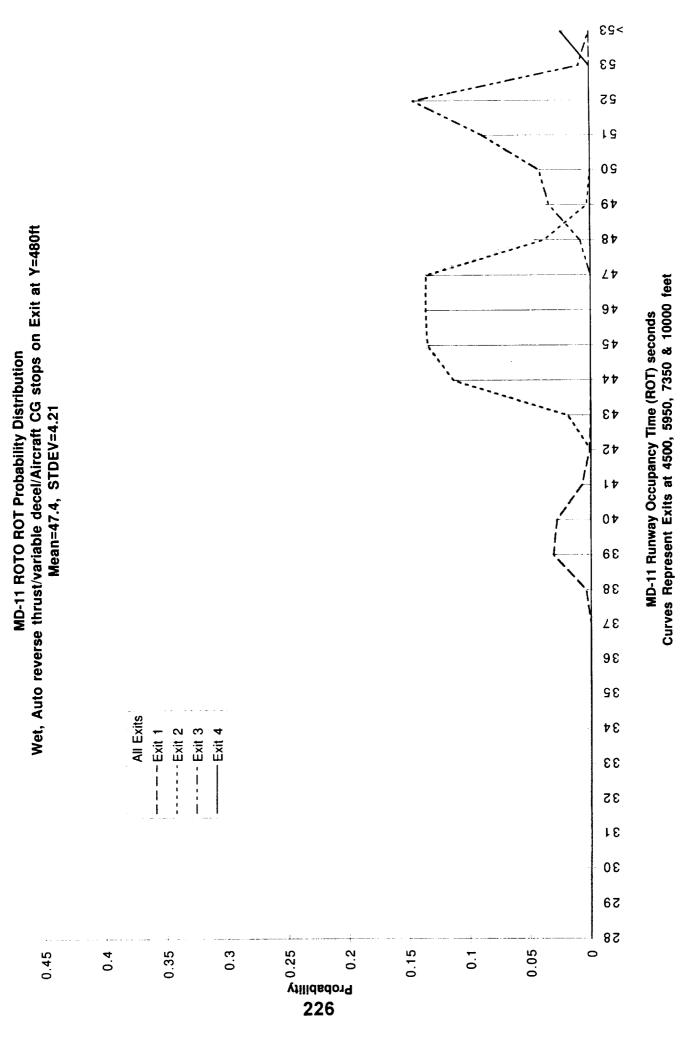


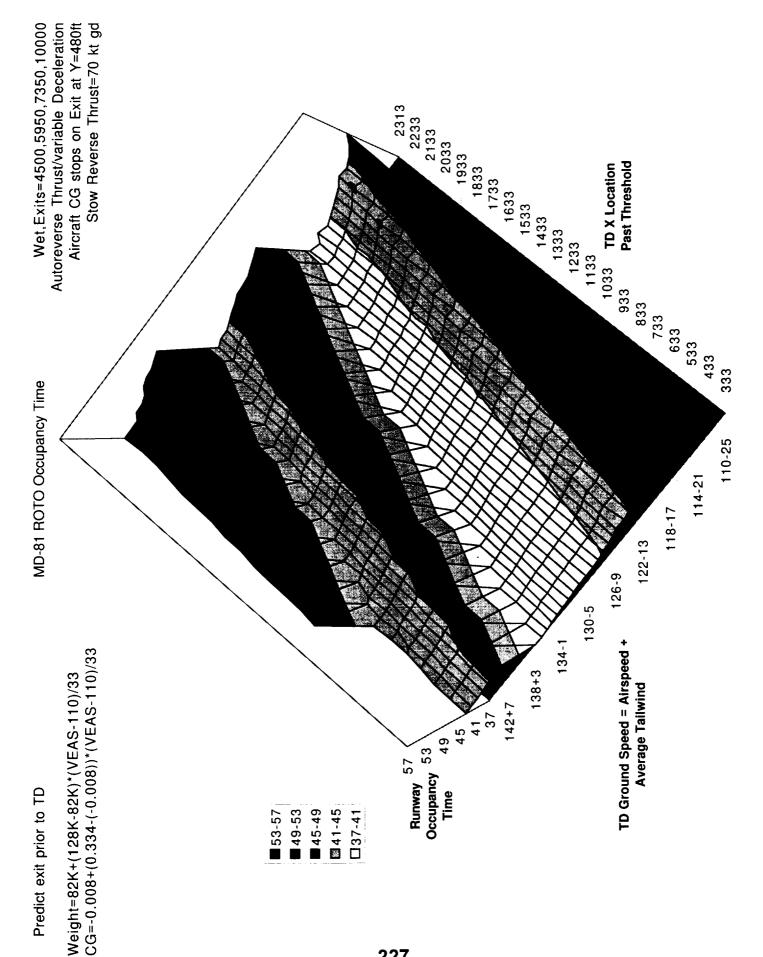
23 25 19 09 61 84 ۷ ل Wet, Auto reverse thrust/variable decel/td lateral offset=27ft Mean=41.5, STDEV=3.433 91 MD-81 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 97 £ 7 0 Þ 33 88 ٤٤ 98 32 **7** ¢ All Exits 33 - Exit 4 - Exit 3 ----- Exit 2 -- Exit 1 35 18 30 58 82 Villidsdor9 0.15 0.05 0.35 0.3 0.45 0.4 0.1 0 224

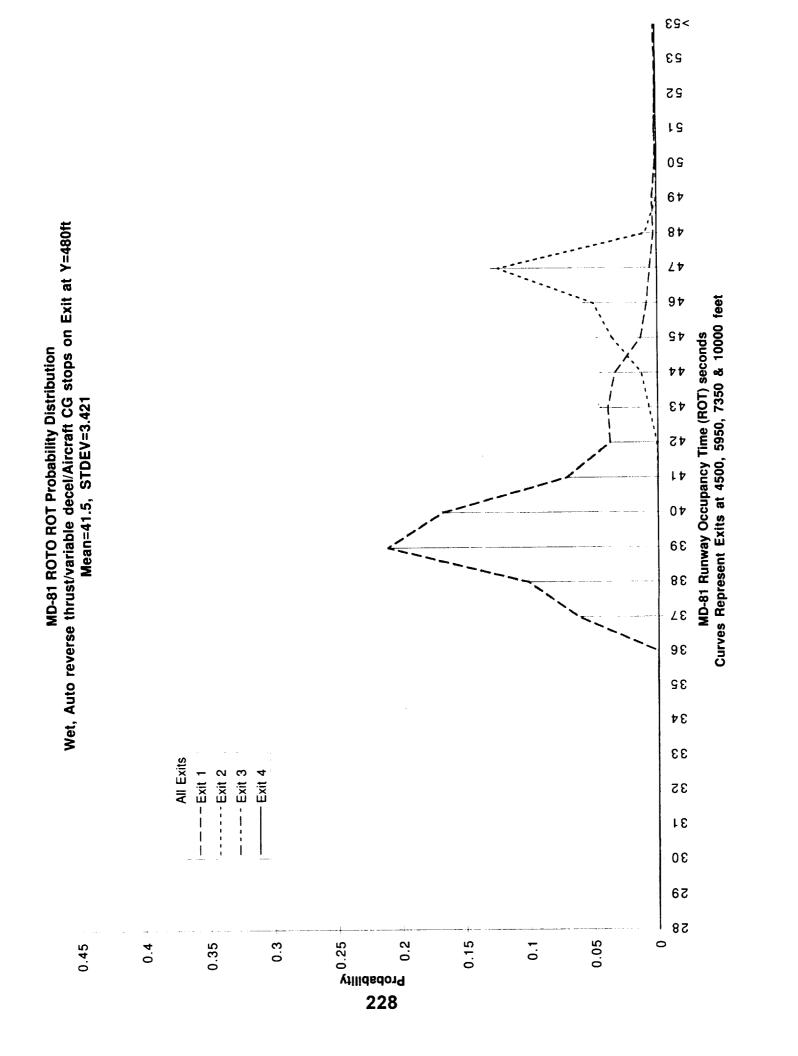
MD-81 ROTO ROT Probability Distribution

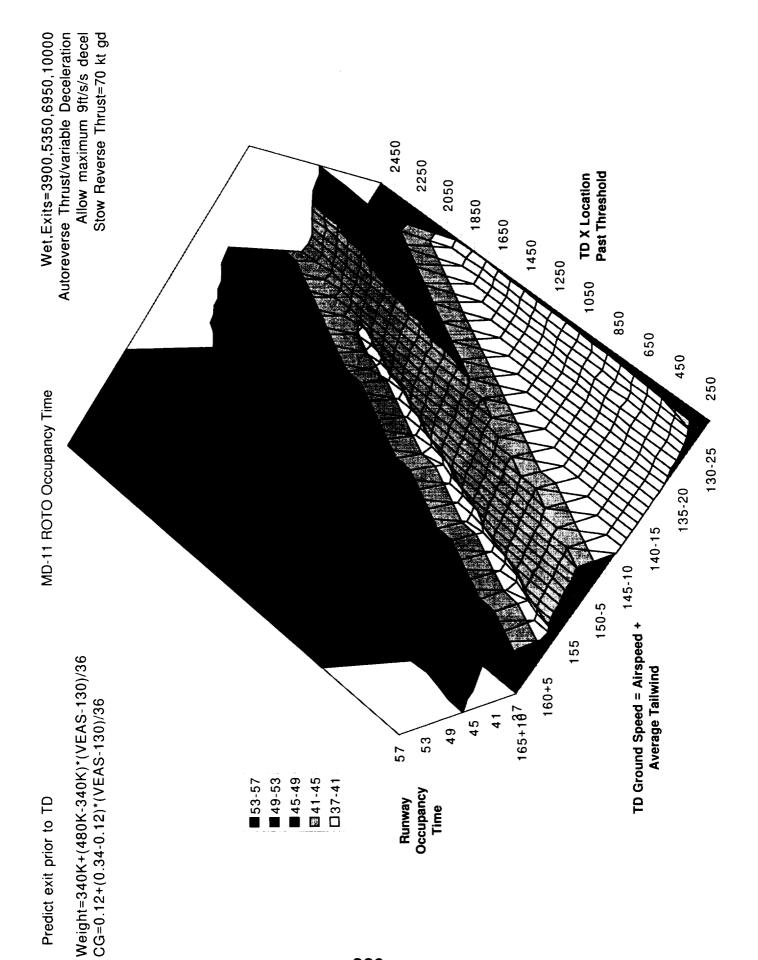
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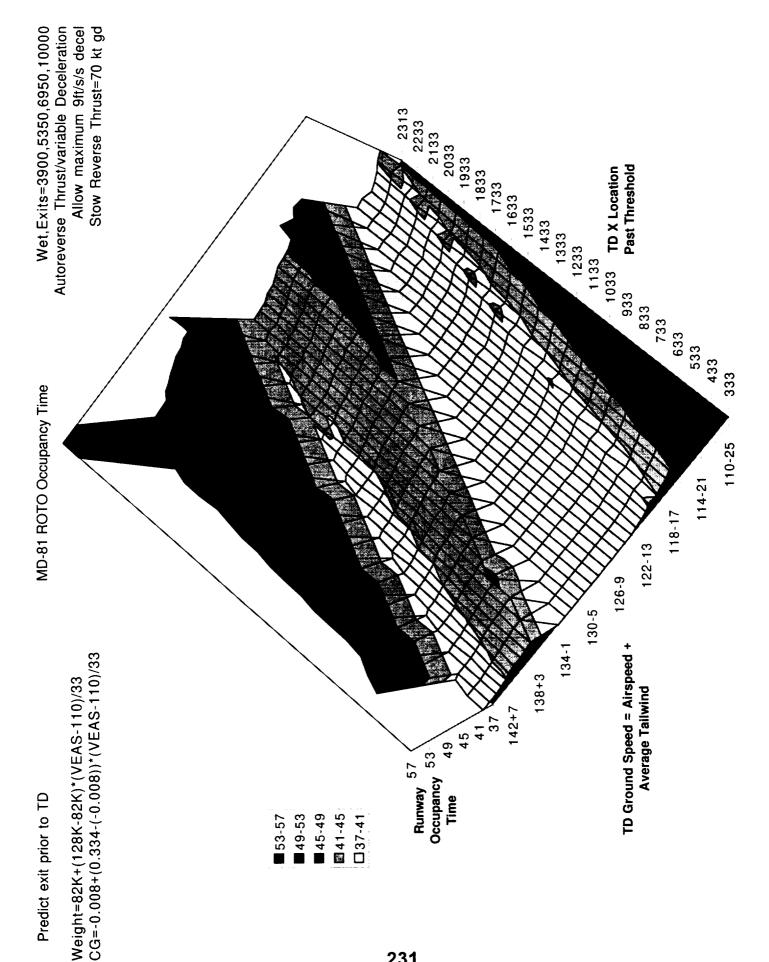


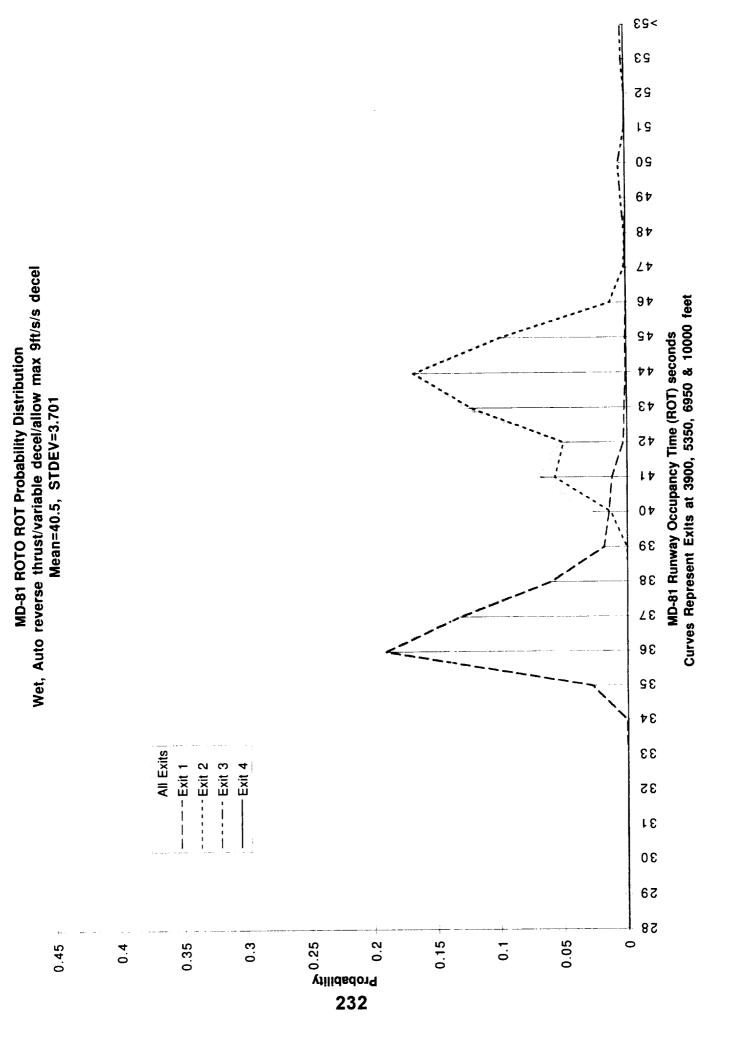


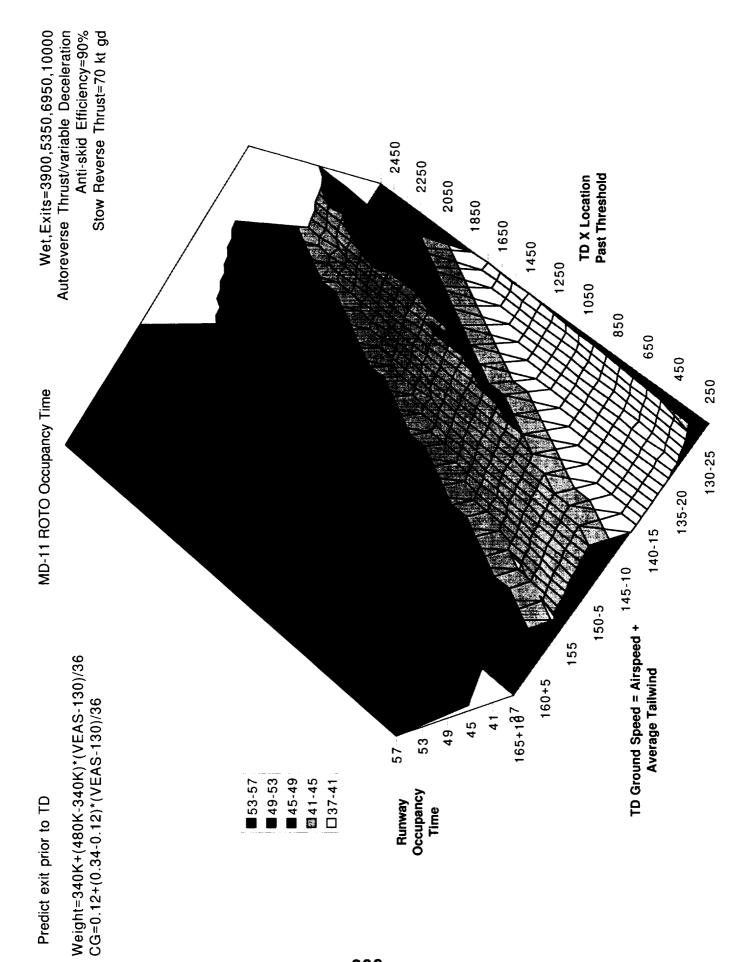
>23 23 25 15 09 6 t 81 Wet, Auto reverse thrust/variable decel/allow max 9ft/s/s decel Mean=45.4, STDEV=4.5 L Þ 91 97 **t**3 45 17 01 6ε 8€ **Σ** 9€ 32 All Exits Exit 3 Exit 4 ----- Exit 2 34 - Exit 1 33 35 18 30 58 82 730 Villidadora SS 0.45 0.35 0.3 0.4 0.15 0.1 0.05 0

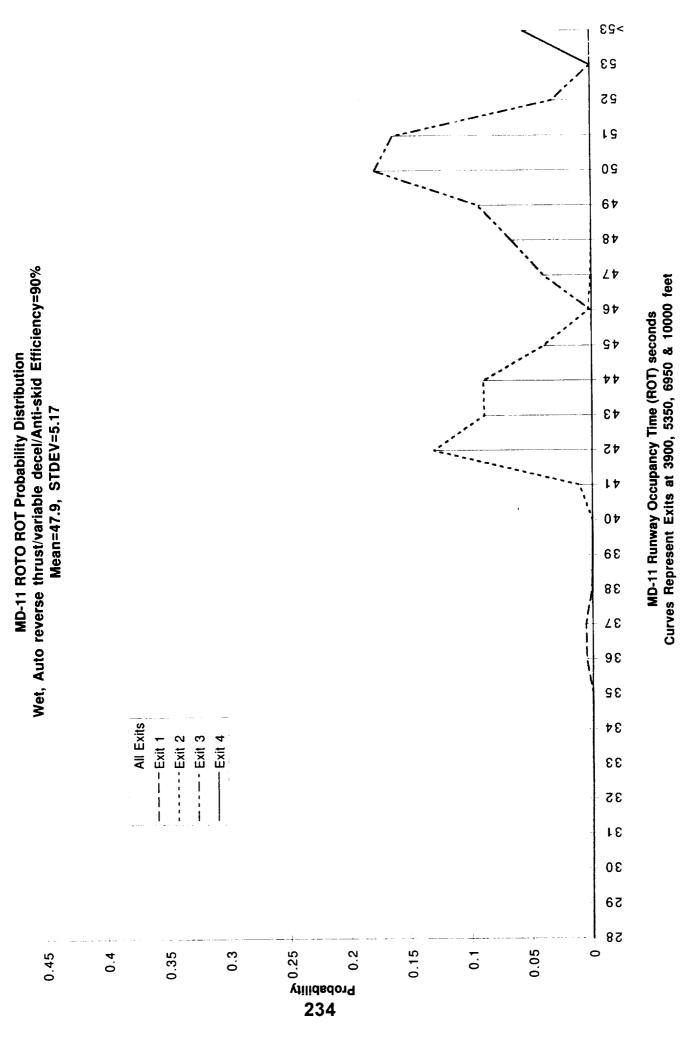
MD-11 ROTO ROT Probability Distribution

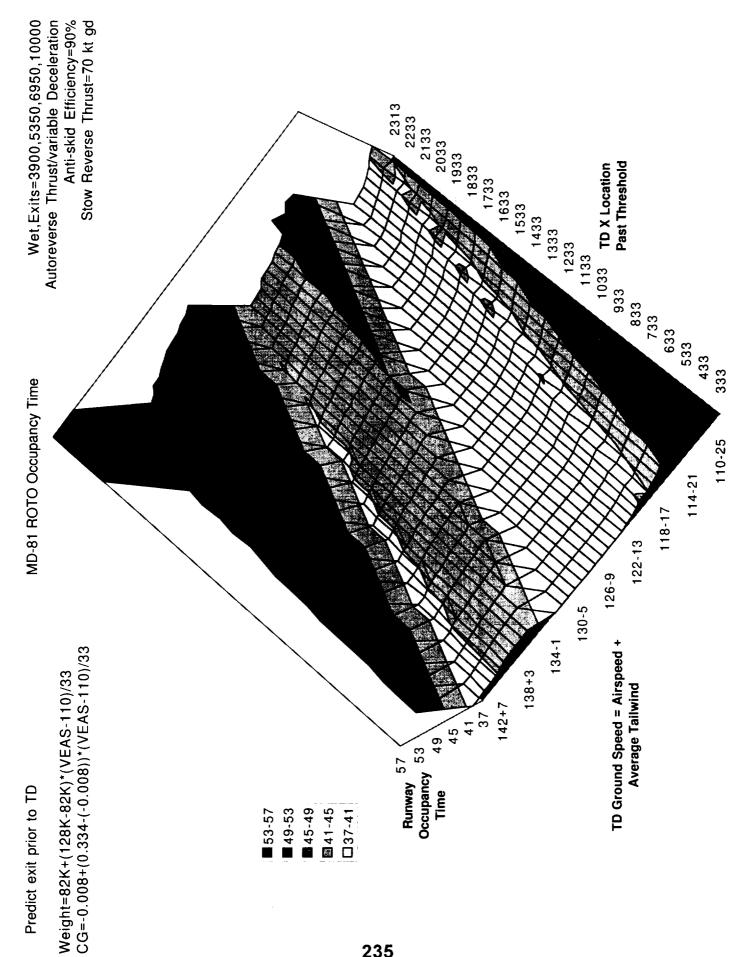
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3900, 5350, 6950 & 10000 feet





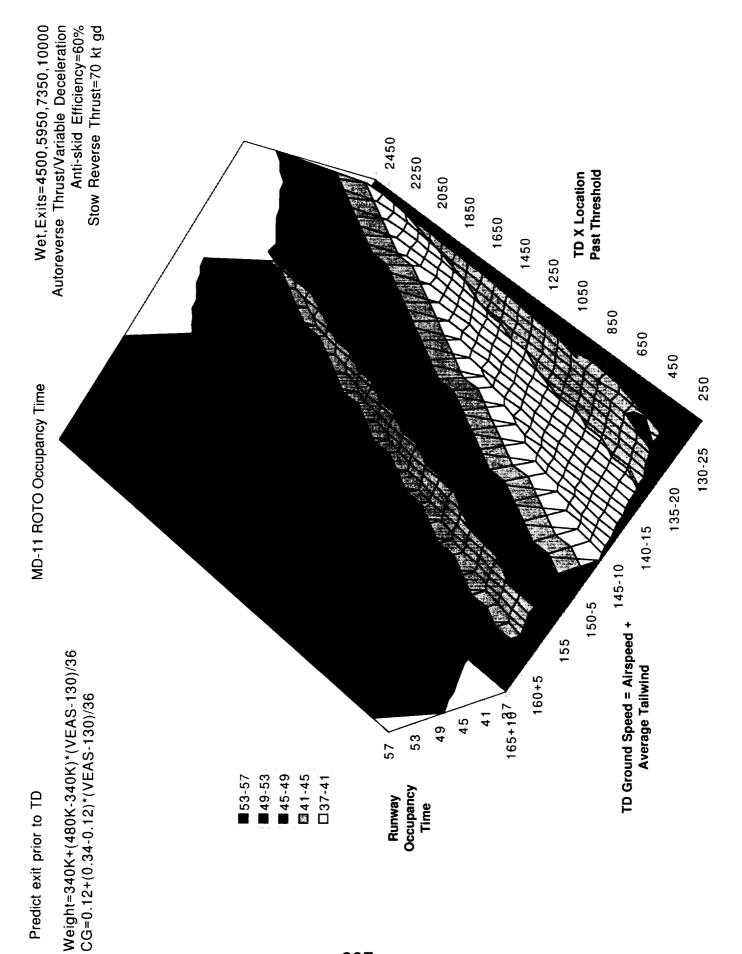


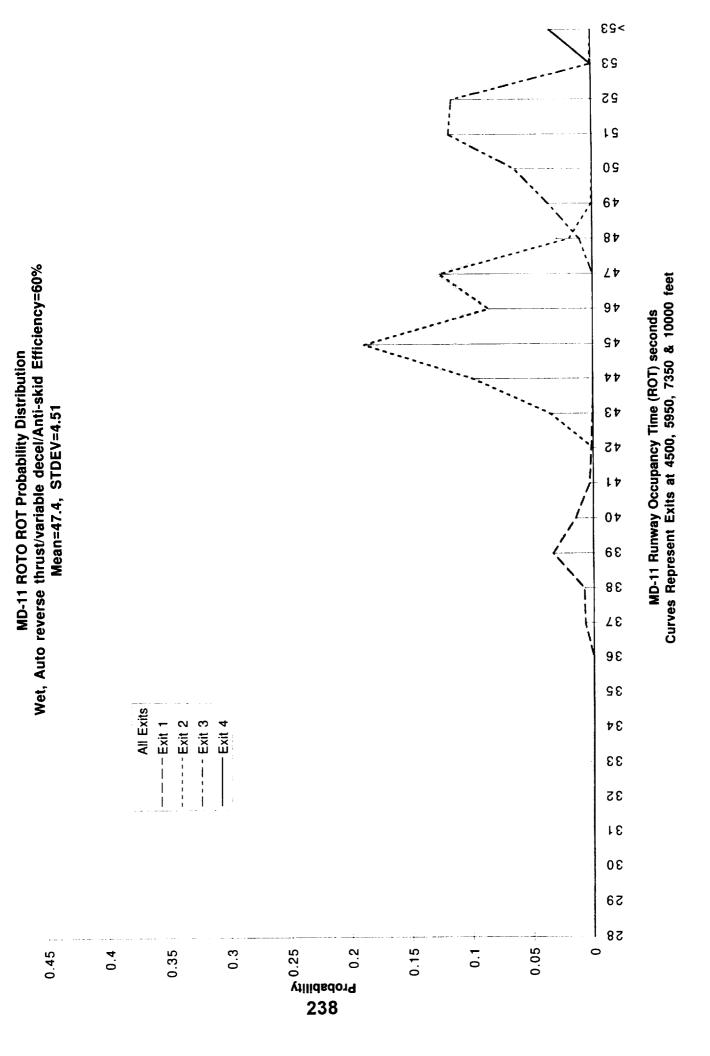


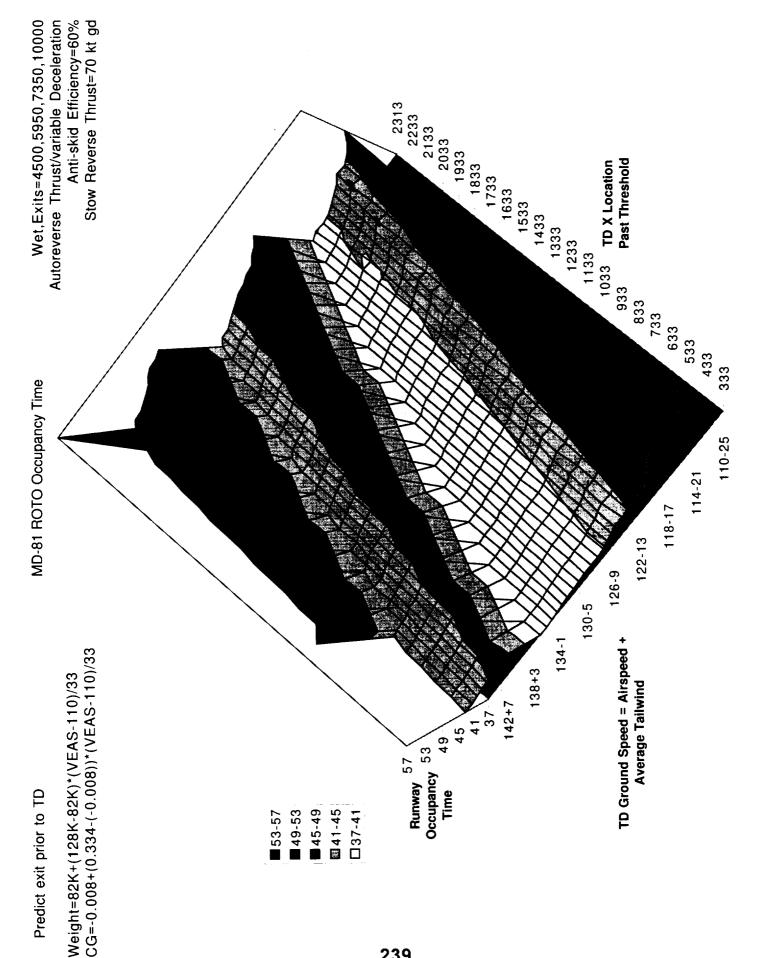


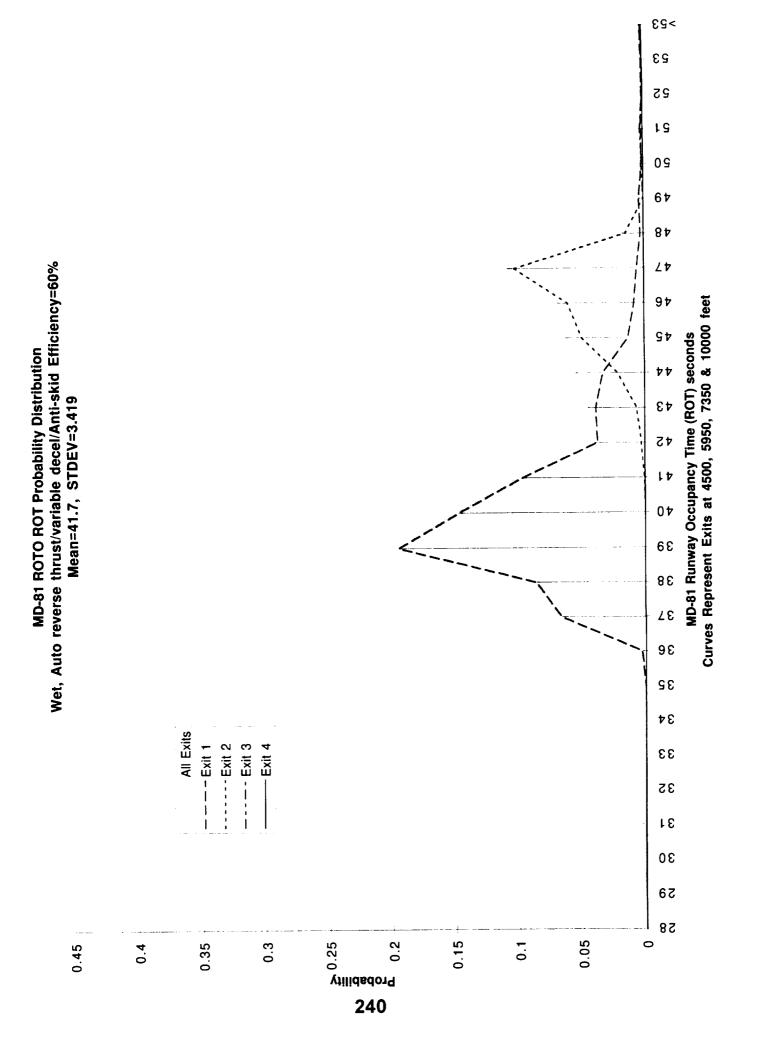
>23 23 25 19 09 6 t 81 Wet, Auto reverse thrust/variable decel/Anti-skid Efficiency=90% Mean=40.9, STDEV=3.833 L 7 91 Curves Represent Exits at 3900, 5350, 6950 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds 45 01 33 88 ٤٤ 98 32 34 33 All Exits .- Exit 3 ----- Exit 2 -- Exit 1 35 18 30 5 82 736 Villidadora 0.3 0.15 0.45 0.35 0.1 0.05 0.4 0

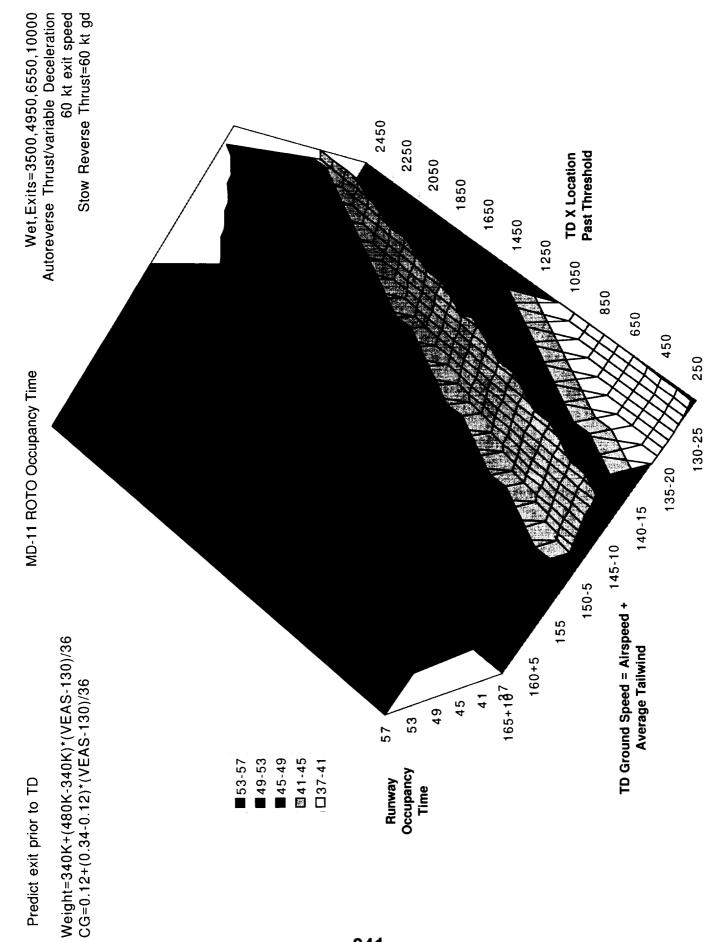
MD-81 ROTO ROT Probability Distribution







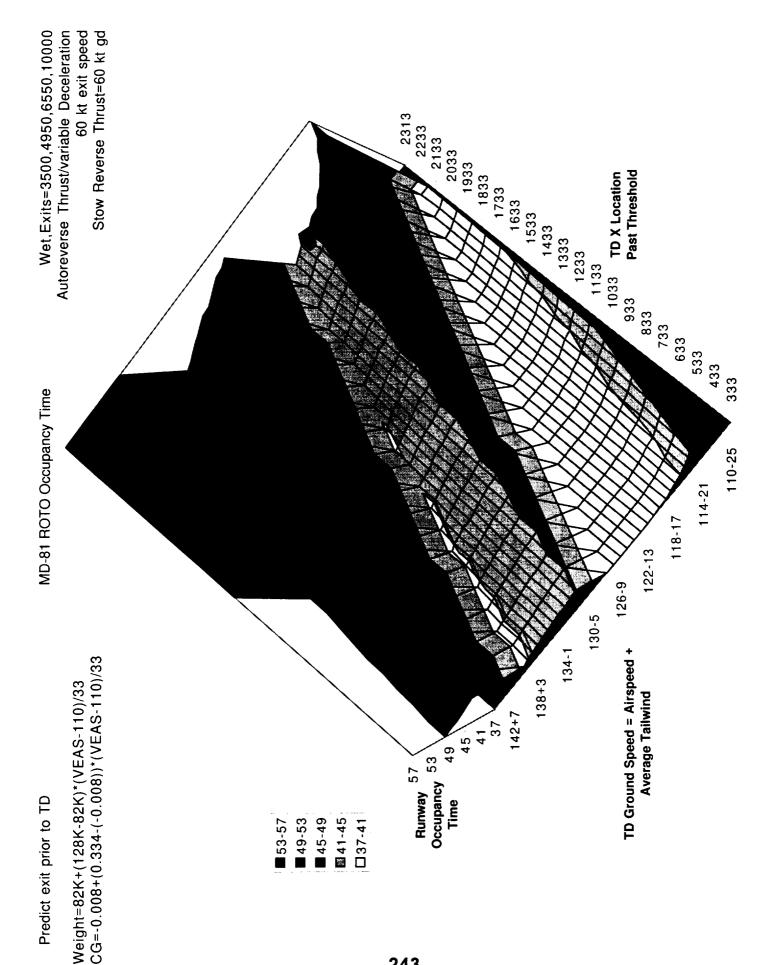




>23 23 25 13 09 6 t 8 Þ ۷ *ل* Wet, Auto reverse thrust/variable decel/60 kt exit speed 91 91 Mean=54, STDEV=8.56 843 45 17 01 38 38 32 98 32 All Exits ₹ - Exit 4 Exit 3 ---- Exit 1 ---- Exit 2 33 35 18 30 58 82 242 Villidadora 0.45 0.35 0.3 0.4 0.15 0.05 0.1 0

MD-11 ROTO ROT Probability Distribution

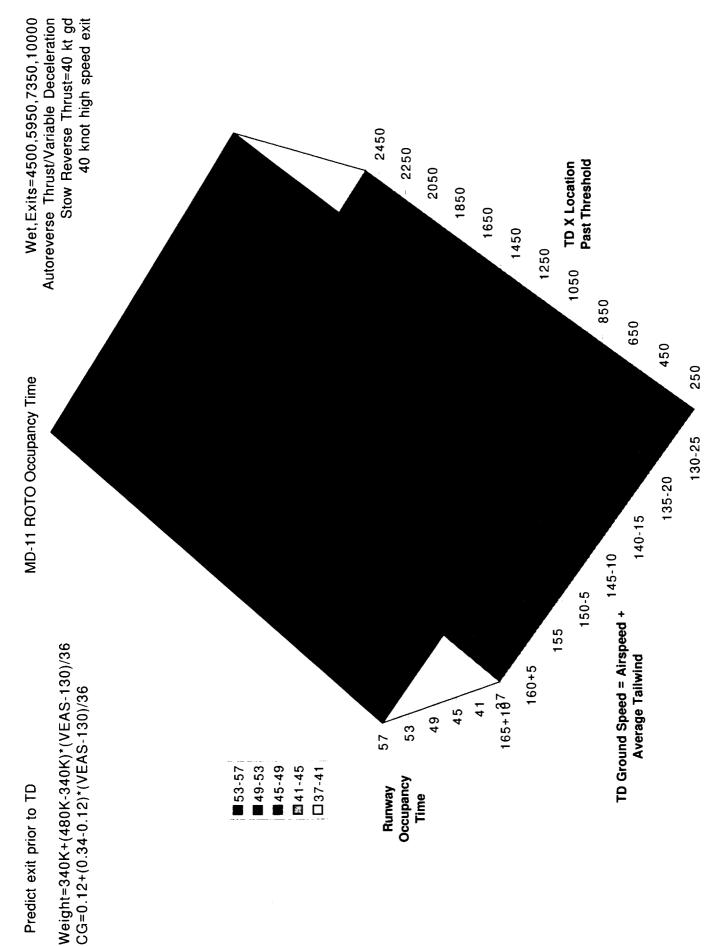
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3500, 4950, 6550 & 10000 feet

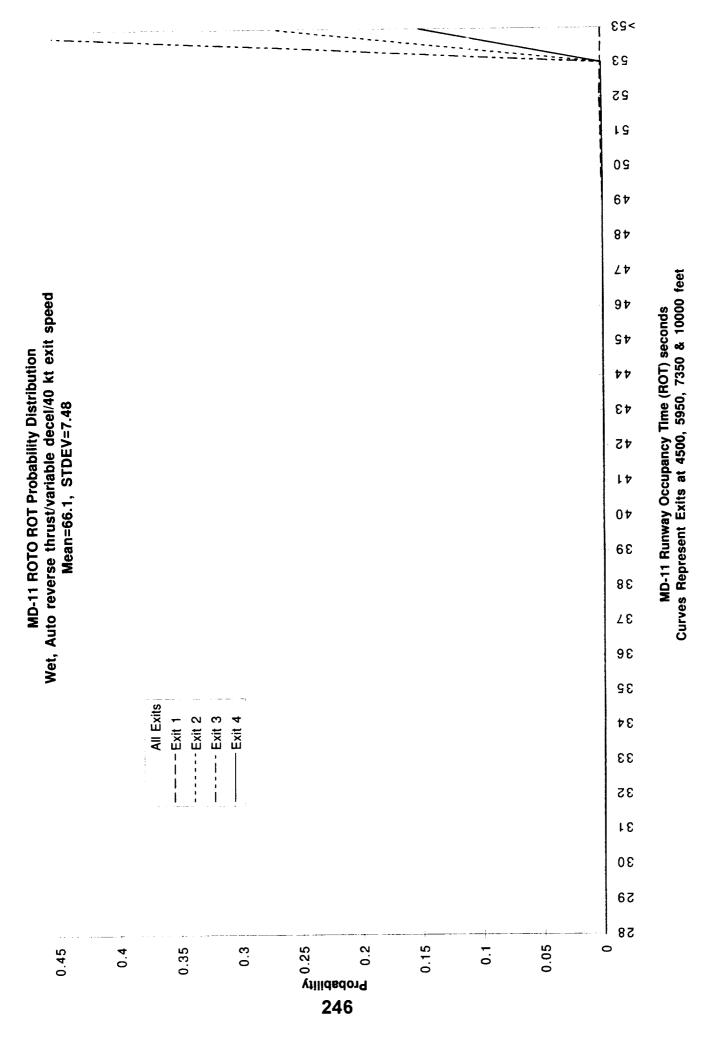


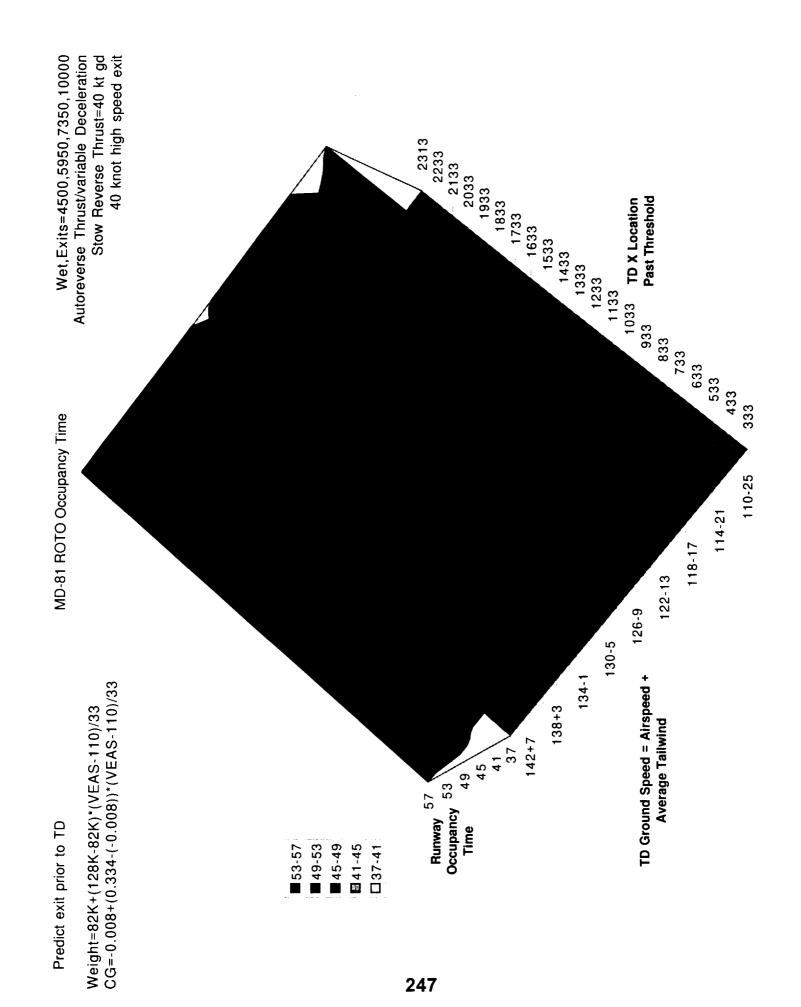
23 25 18 09 6*†* 81 **1** Wet, Auto reverse thrust/variable decel/60 kt exit speed 91 Curves Represent Exits at 3500, 4950, 6550 & 10000 feet 97 MD-81 Runway Occupancy Time (ROT) seconds t t Mean=44.7, STDEV=4.174 45 38 38 ٤٤ 98 32 34 All Exits ----Exit 1 ----- Exit 2 -- Exit 3 33 35 15 30 58 88 Villidsdor9
0.25 0.05 0.15 0.35 0.3 0.2 0.1 0 0.45 4.0 244

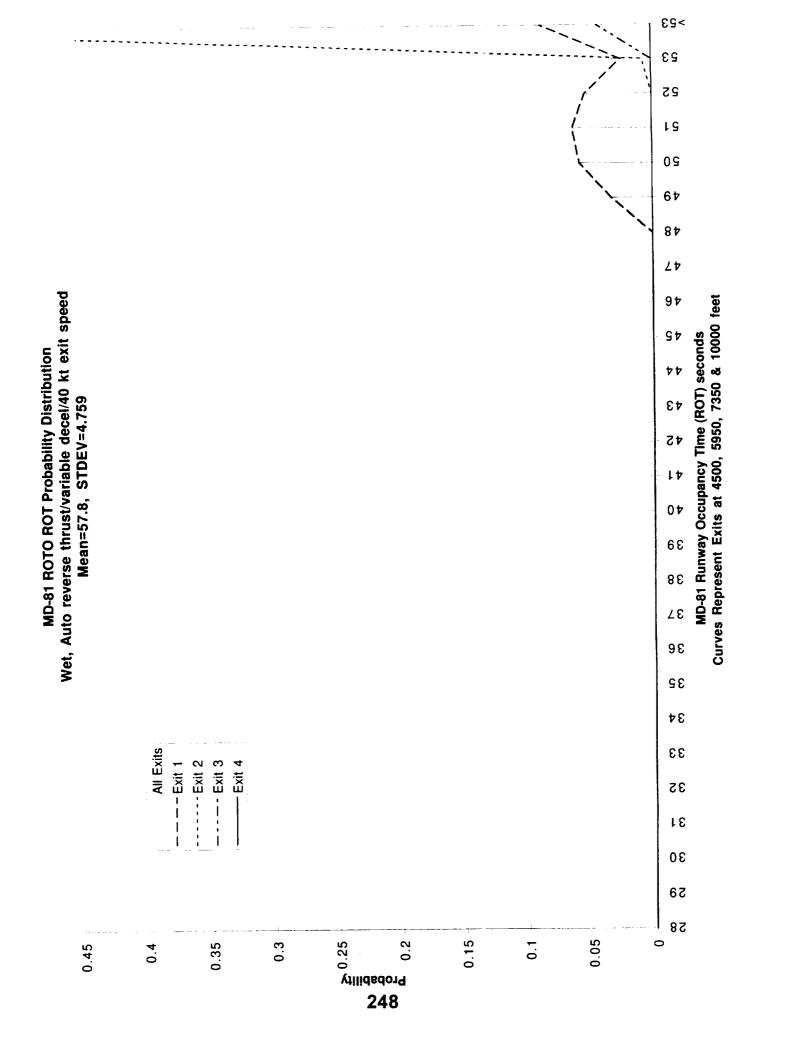
MD-81 ROTO ROT Probability Distribution

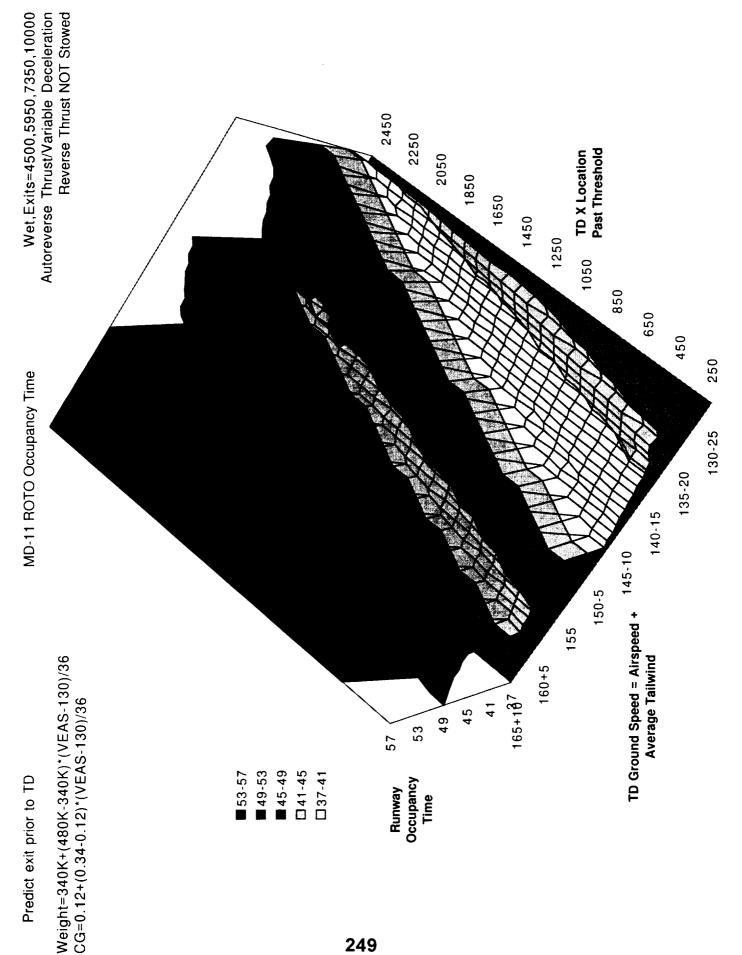
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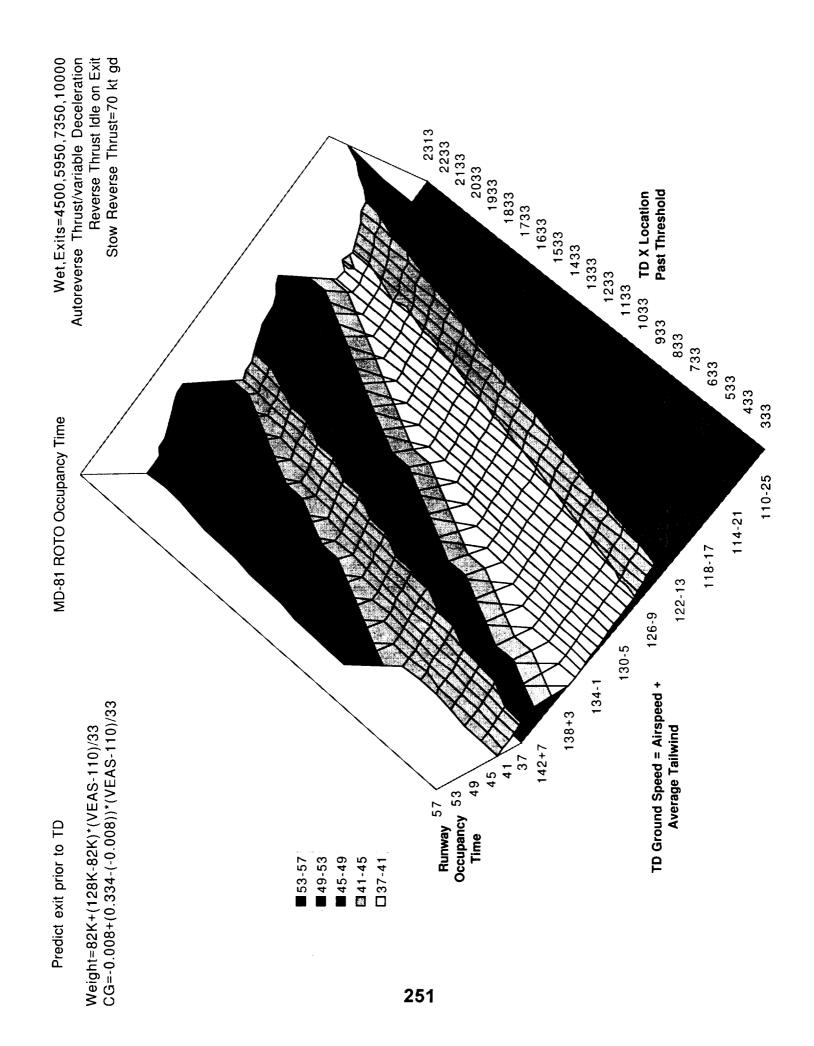






23 25 19 09 6 Þ 8 7 Wet, Auto reverse thrust/variable decel/Reverse Thrust NOT Stowed L Þ 9 7 97 **MD-11 ROTO ROT Probability Distribution** t t Mean=47.3, STDEV=4.21 **t**3 45 1 1 0 ಶ 38 88 ٤٤ 98 32 **⊅**€ All Exits - Exit 4 -- Exit 2 - Exit 3 - Exit 1 33 35 15 30 58 82 Probability 0.25 0.35 0.45 0.3 0.15 0.1 0.05 0 0.4 250

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



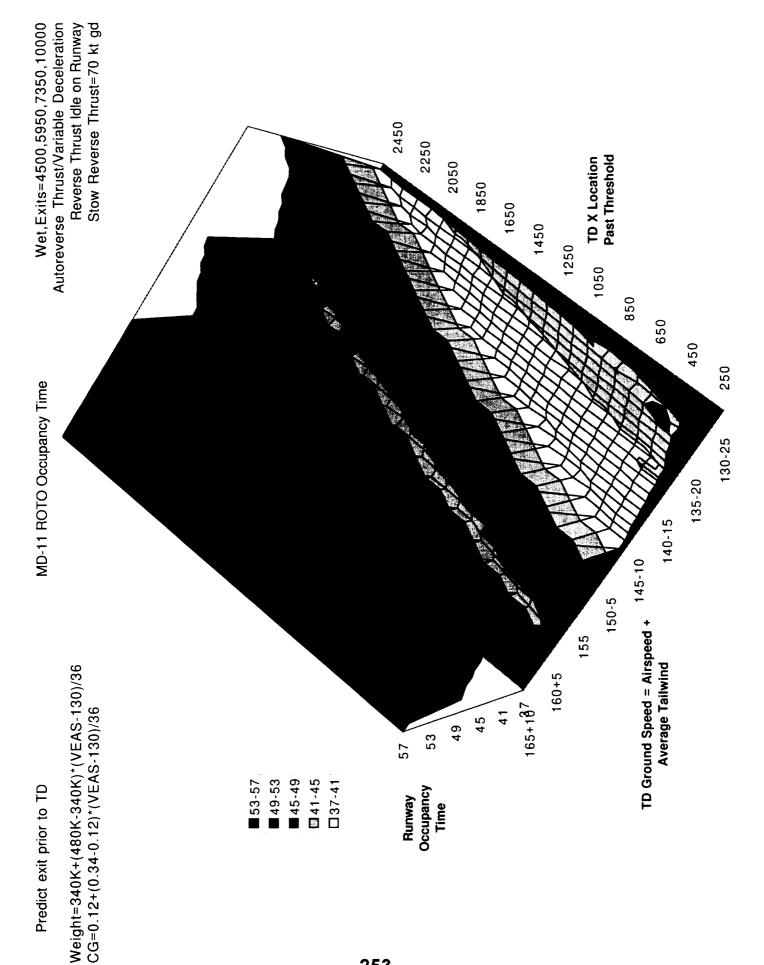
25 19 09 6*†* 81 Wet, Auto reverse thrust/variable decel/Reverse Thrust NOT Stowed Mean=41.9, STDEV=3.897 ۷ ا 91 97 MD-81 Runway Occupancy Time (ROT) seconds MD-81 ROTO ROT Probability Distribution 43 45 0 Þ 38 38 ٤٤ 98 32 34 33 All Exits -- Exit 1 ----- Exit 2 ---- Exit 3 35 15 30 58 82 Villidsdor9 0.1 0.05 0.5 0.15 0.3 0 0.4 0.35 0.45

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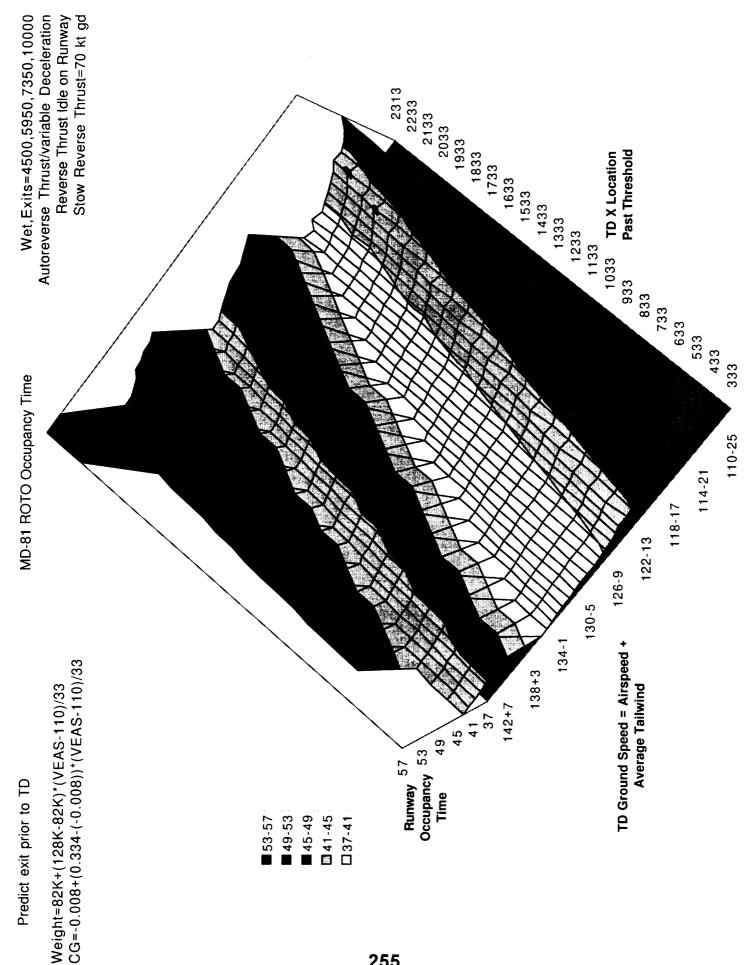
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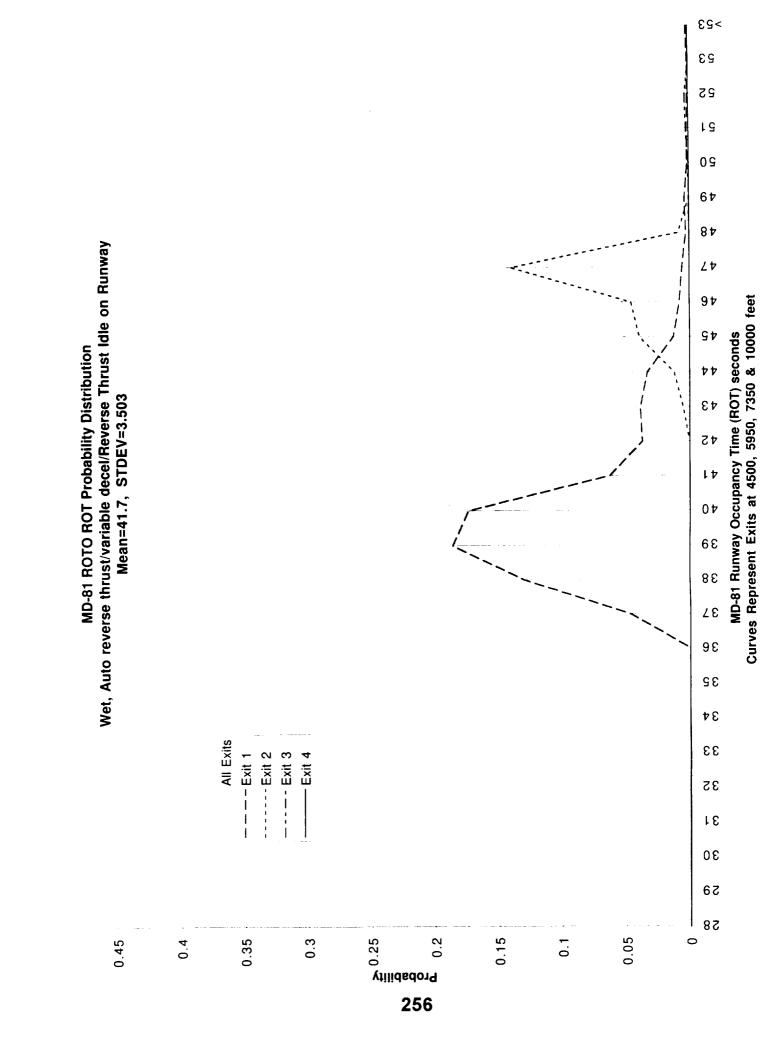
Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

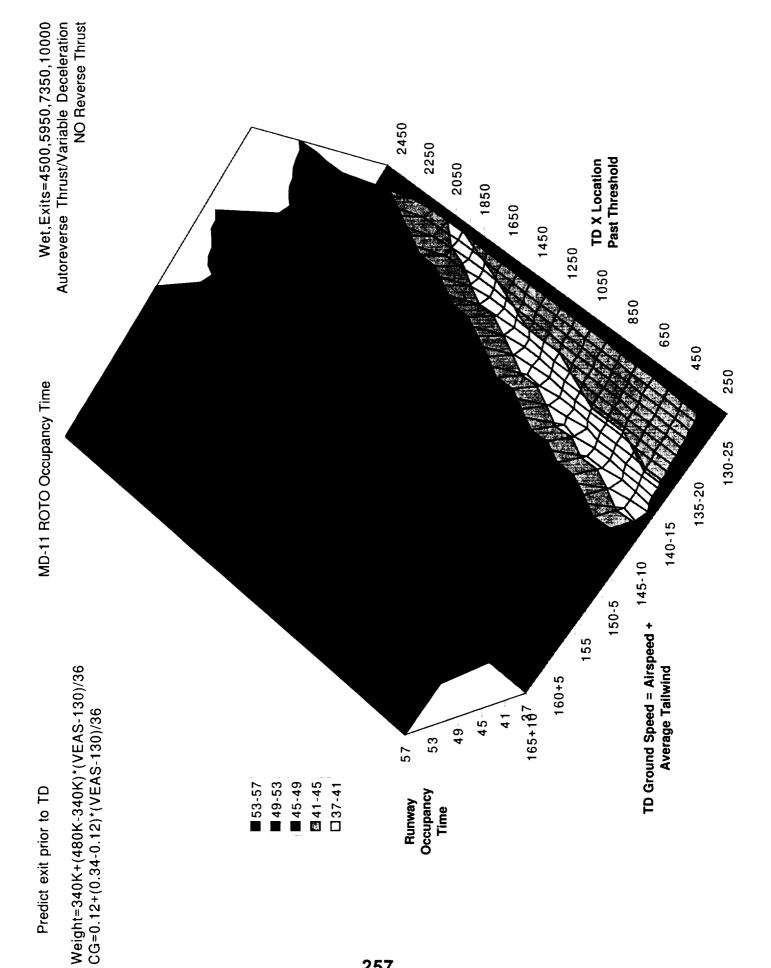


23 25 19 ٥9 6 Þ 81 Wet, Auto reverse thrust/variable decel/Reverse Thrust Idle on Runway **۷** ل 91 97 **MD-11 ROTO ROT Probability Distribution** t t Mean=48.8, STDEV=5.04 87 75 17 01 38 88 2Σ 98 32 All Exits - Exit 3 ----- Exit 2 34 -- Exit 1 33 35 18 30 58 82 254 Villidedorq 0.05 0.45 0.4 0.35 0.3 0.15 0.1 0

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

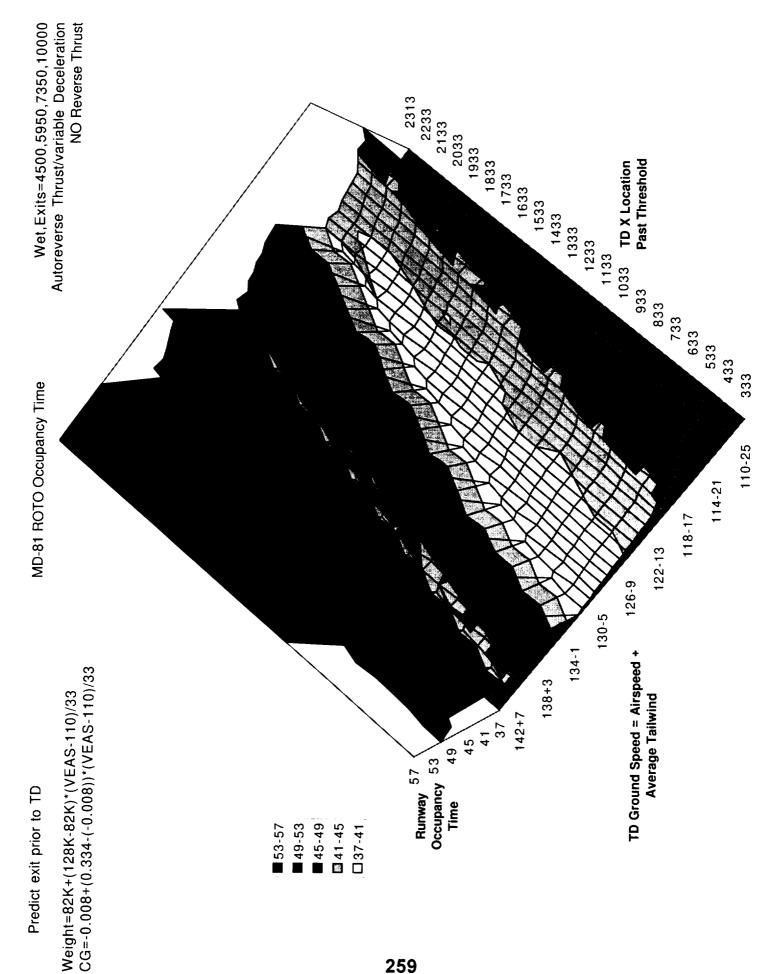






23 25 19 09 6*†* 8 7 ۷ **۲** Wet, Auto reverse thrust/variable decel/NO Reverse Thrust 9 t 97 **MD-11 ROTO ROT Probability Distribution** t t Mean=53.3, STDEV=6.61 **t**3 45 10 01 38 38 37 98 All Exits 32 .- Exit 3 - Exit 4 ----Exit 1 ----- Exit 2 7 t 33 35 18 30 58 82 Villidsdor9 0.45 0.4 0.35 0.3 0.15 0.05 0.2 0.1 0 258

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



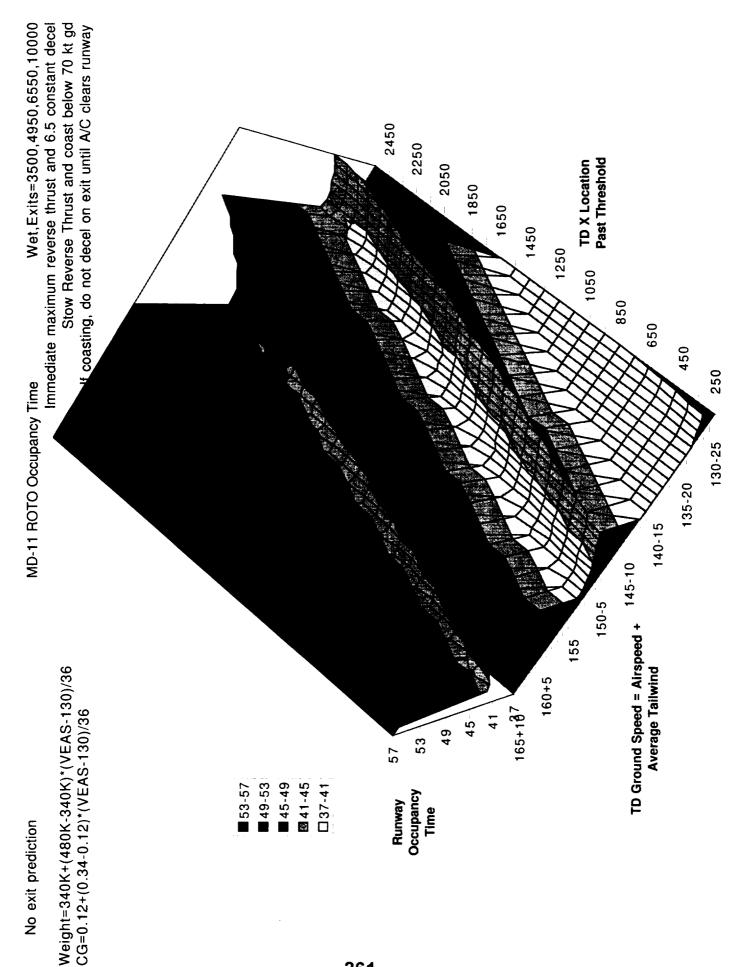
25 19 09 6₺ 81 ۷ ل Wet, Auto reverse thrust/variable decel/NO Reverse Thrust Mean=43.7, STDEV=4.287 9 t 97 MD-81 Runway Occupancy Time (ROT) seconds MD-81 ROTO ROT Probability Distribution €⊅ 45 38 38 **Σ** 98 32 ₹ All Exits 33 - Exit 4 ----- Exit 2 ----- Exit 3 ----Exit 1 35 31 30 58 82 0.05 Villidsdor9 0.25 0.15 0.1 0 0.4 0.2 0.35 0.3 0.45

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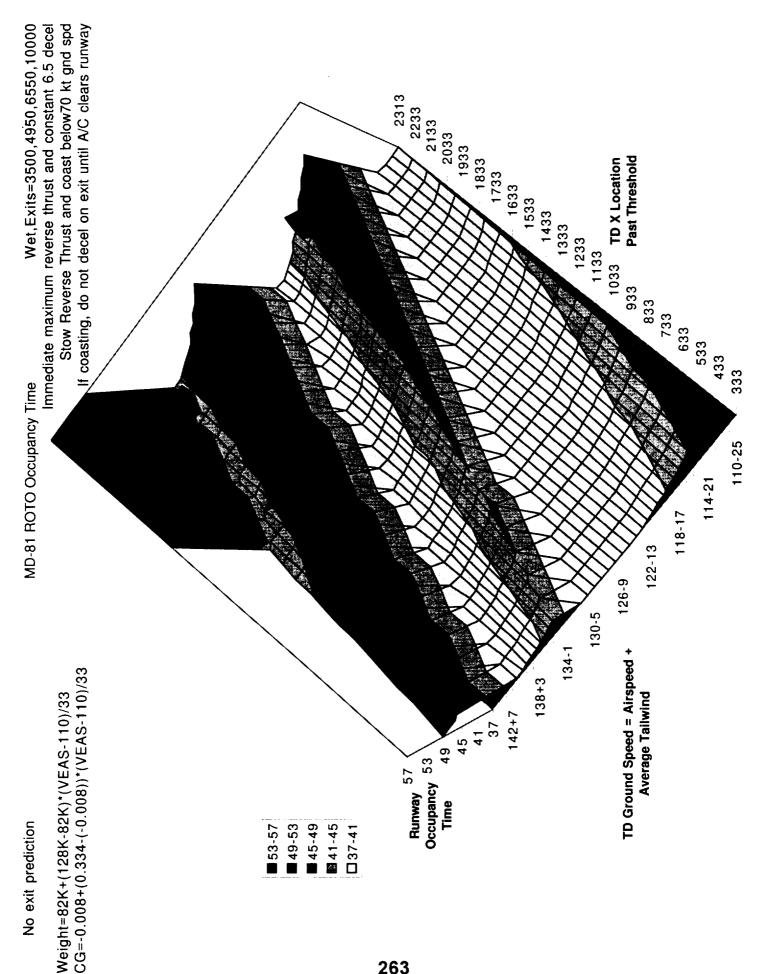
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Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

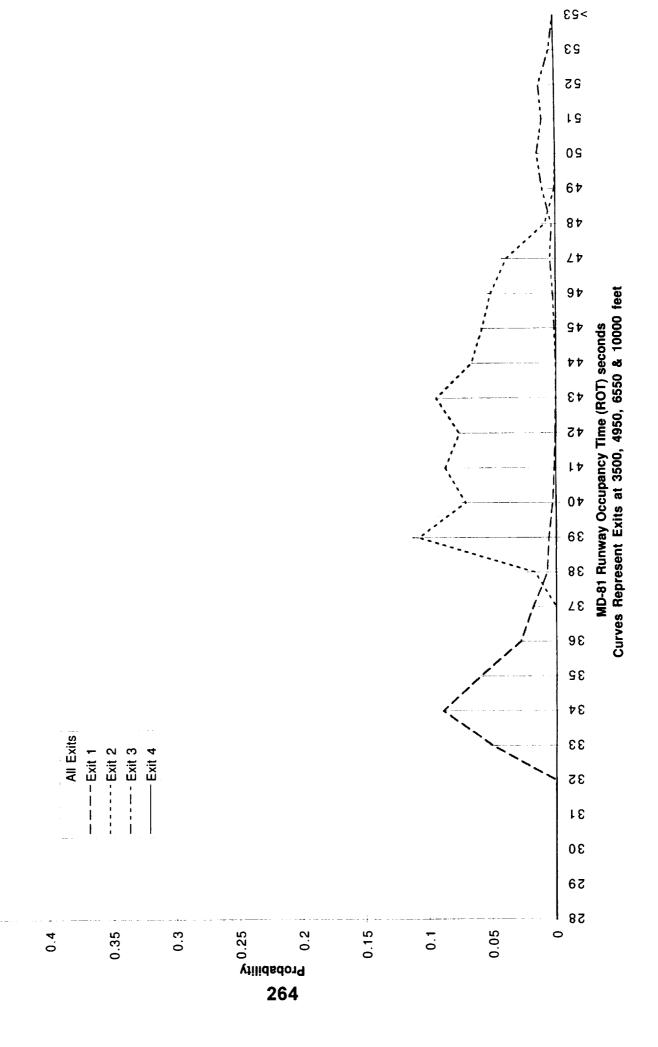


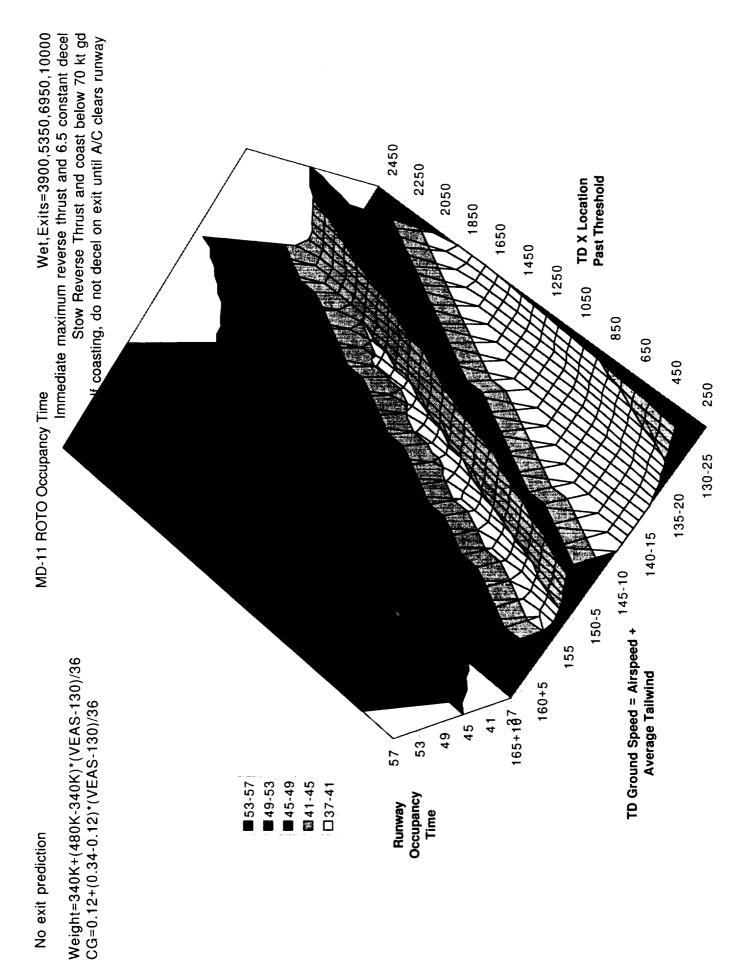
23 25 19 09 6*†* 81 **1** 91 Wet, Maximum reverse thrust/constant 6.5 decel Mean=48, STDEV=8.89 97 **MD-11 ROTO ROT Probability Distribution** 43 45 17 0 Þ 38 38 ٤٤ 98 32 All Exits 34 - Exit 3 Exit 4 ----- Exit 2 ----Exit 1 33 35 18 30 58 82 792 Villidadora 0.15 0.45 0.4 0.35 0.3 0.05 0 0.1

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3500, 4950, 6550 & 10000 feet



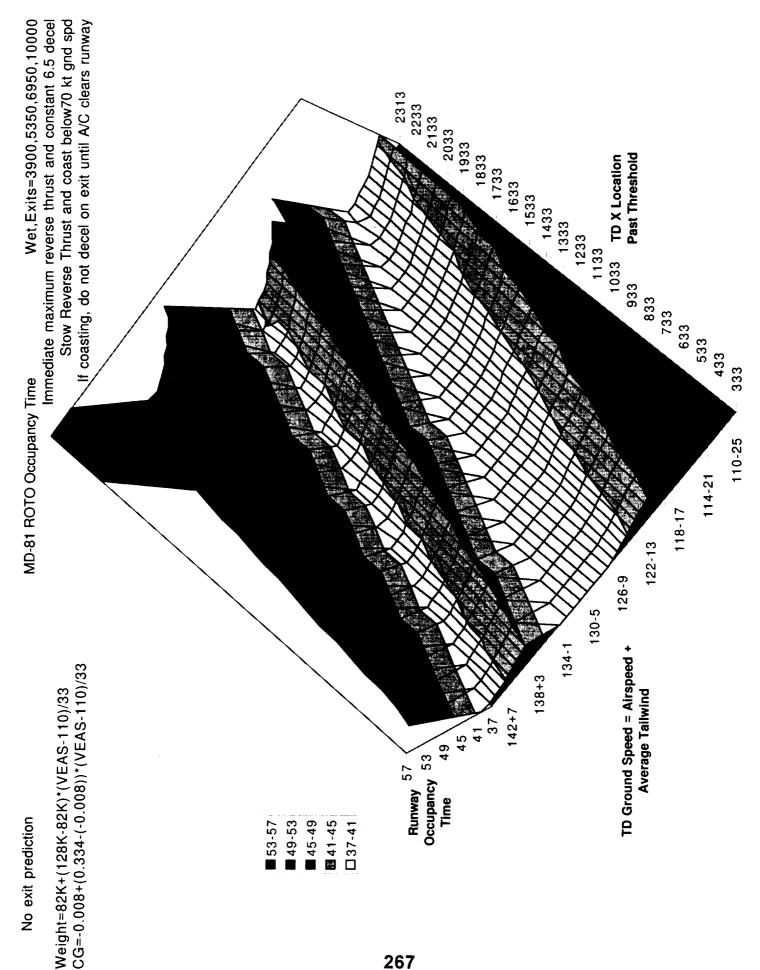
MD-81 ROTO ROT Probability Distribution Wet, Maximum reverse thrust/constant 6.5 decel Mean=40.8, STDEV=4.654



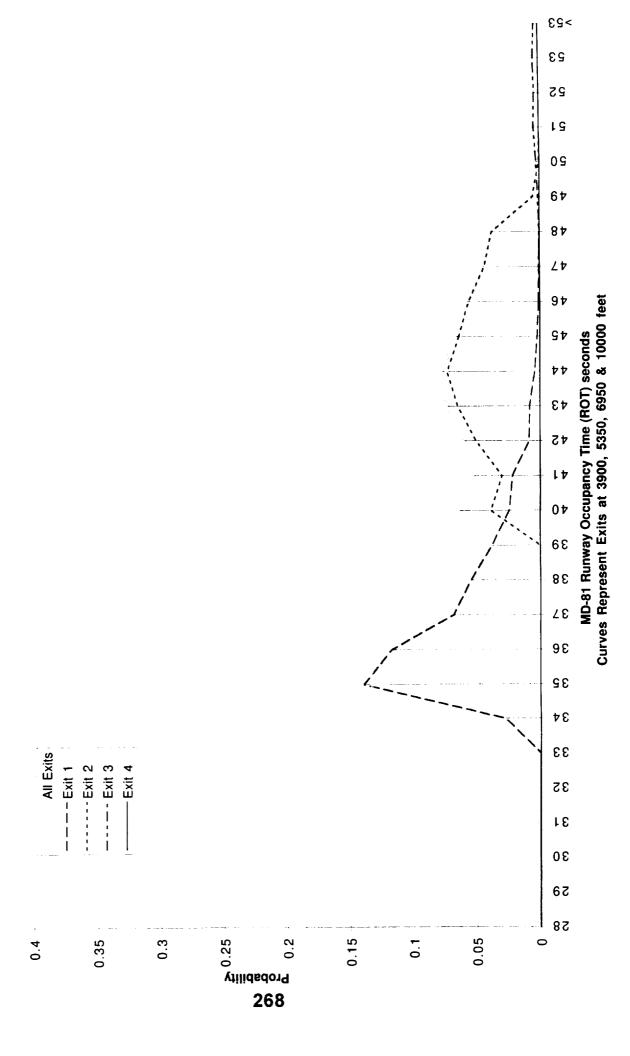


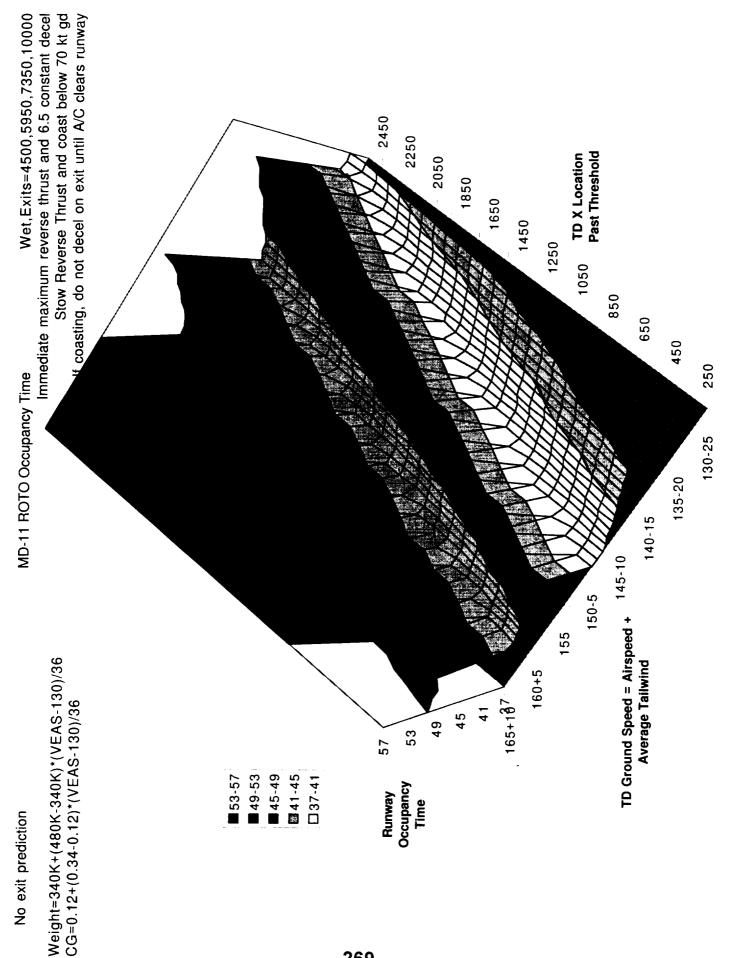
23 25 19 09 6*†* 81 L 7 91 Wet, Maximum reverse thrust/constant 6.5 decel Mean=46.9, STDEV=6.59 97 £ \$ 45 17 01 38 38 37 98 32 All Exits -----Exit 2 ₹ ----Exit 1 33 35 15 30 58 82 266 0.35 0.3 0.15 0.05 0.1 0 0.45 0.4

MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3900, 5350, 6950 & 10000 feet



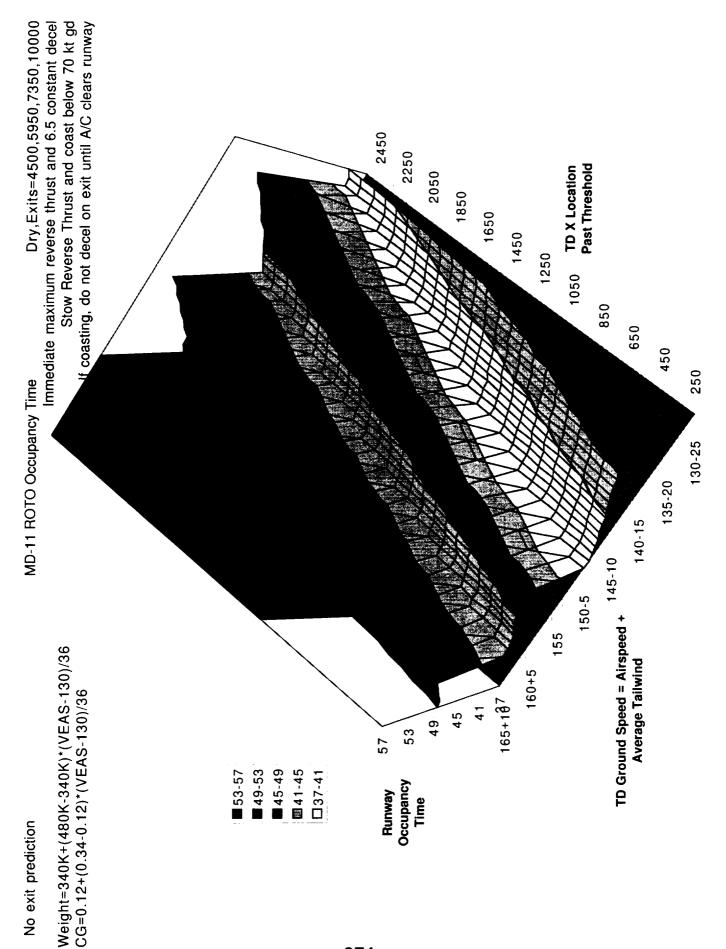
MD-81 ROTO ROT Probability Distribution Wet, Maximum reverse thrust/constant 6.5 decel Mean=40.5, STDEV=4.537



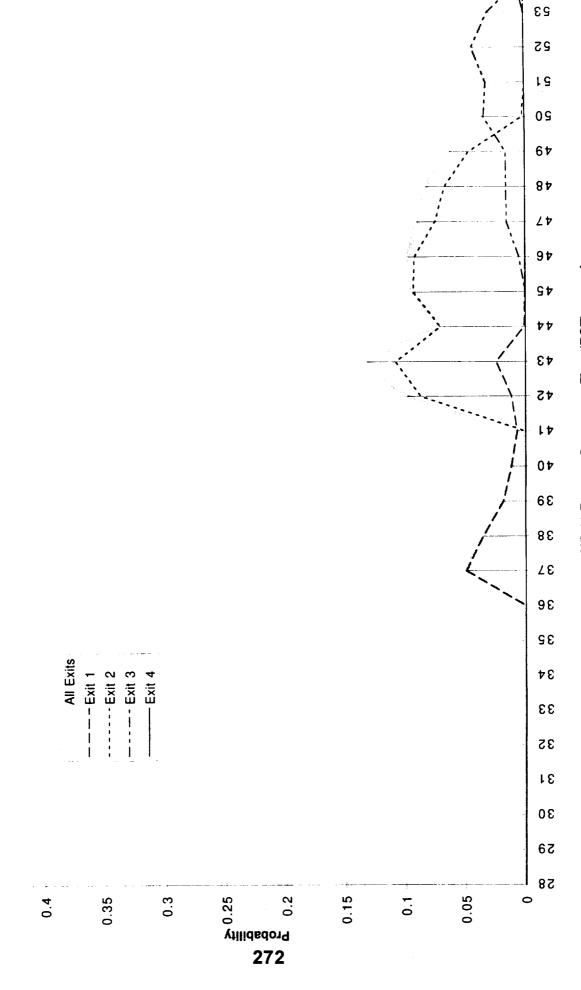


53 25 19 09 6Þ 81 L 7 91 Wet, Maximum reverse thrust/constant 6.5 decel Mean=45.9, STDEV=5.04 97 p p 43 45 17 0 t 38 38 32 98 32 All Exits ----- Exit 2 ----- Exit 3 34 ----Exit 1 $\epsilon\epsilon$ 35 34 30 58 82 270 Villdadorq 5.5 0.15 0.1 0.05 0 0.45 0.4 0.35 0.3

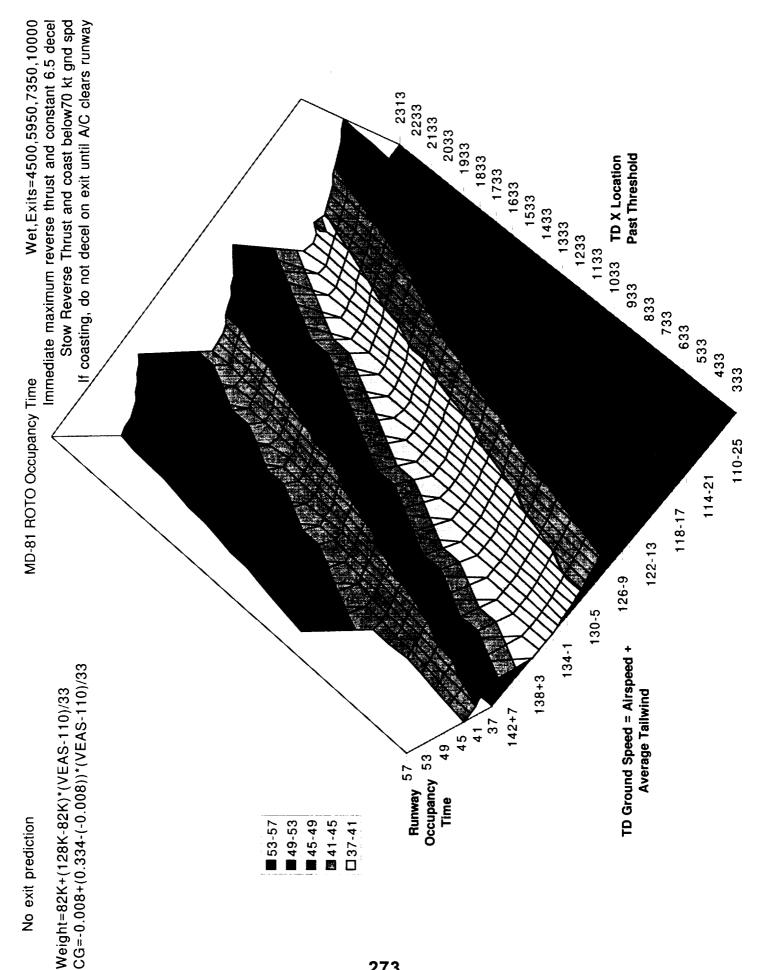
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



MD-11 ROTO ROT Probability Distribution Dry, Maximum reverse thrust/constant 6.5 decel Mean=45.3, STDEV=4.3



MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet



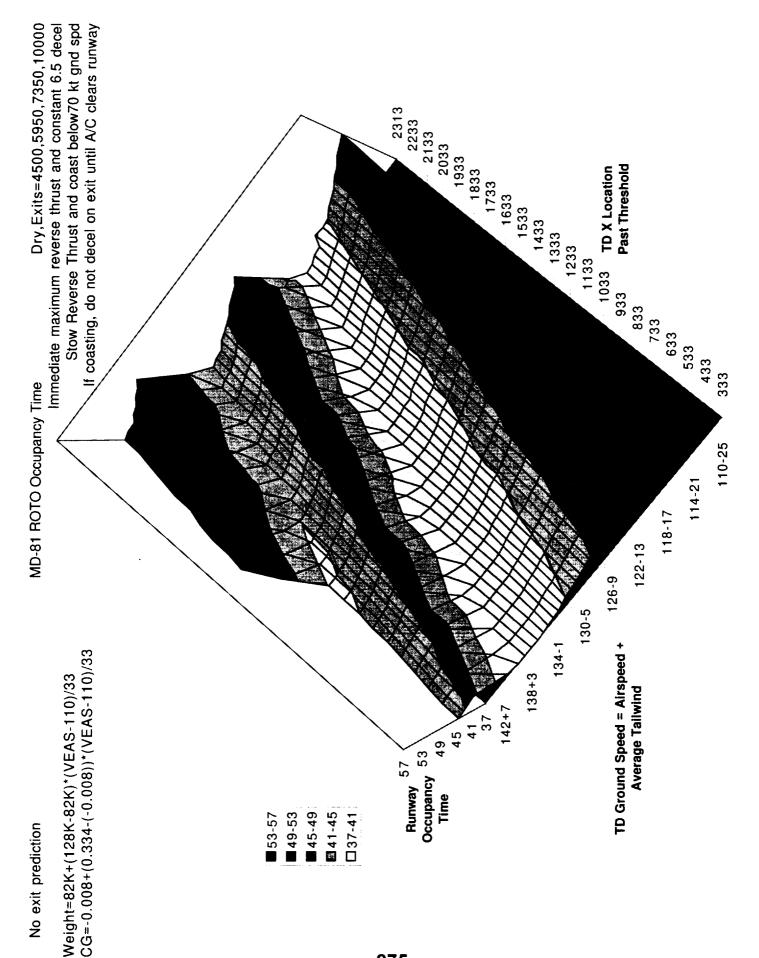
23 25 19 09 6 t 81 ۷7 MD-81 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet 91 97 £\$ 39 38 ٤٤ 98 32 34 33 All Exits - Exit 3 Exit 4 .----- Exit 2 ----Exit 1 35 15 30 58 82 Villidadorq 0.25 0.35 0.3 0.2 0.15 0.05 0 0.4 0.1 274

Wet, Maximum reverse thrust/constant 6.5 decel

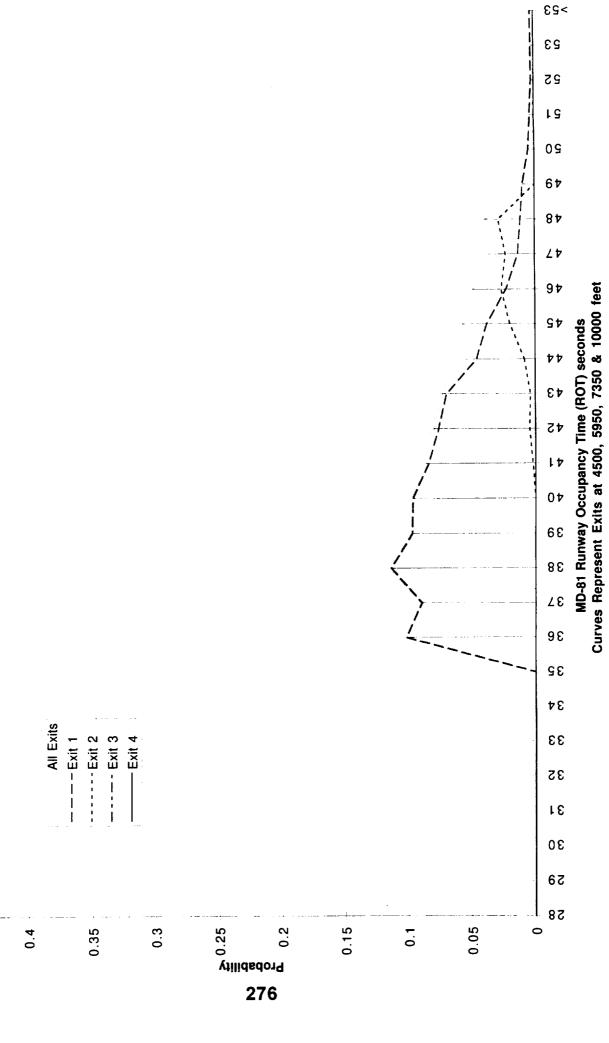
Mean=41.9, STDEV=4.066

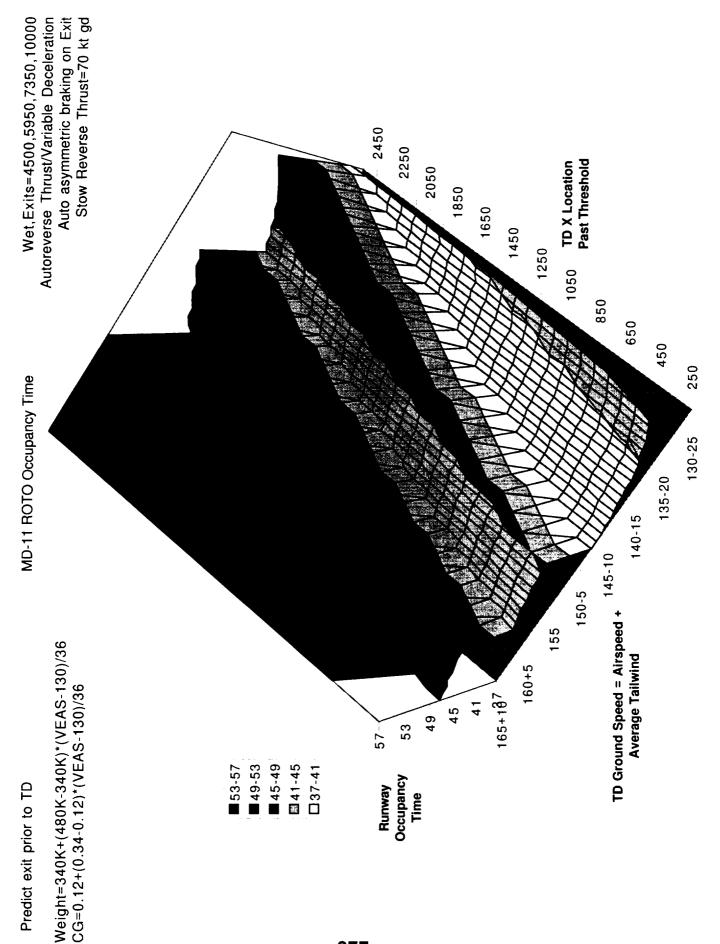
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MD-81 ROTO ROT Probability Distribution



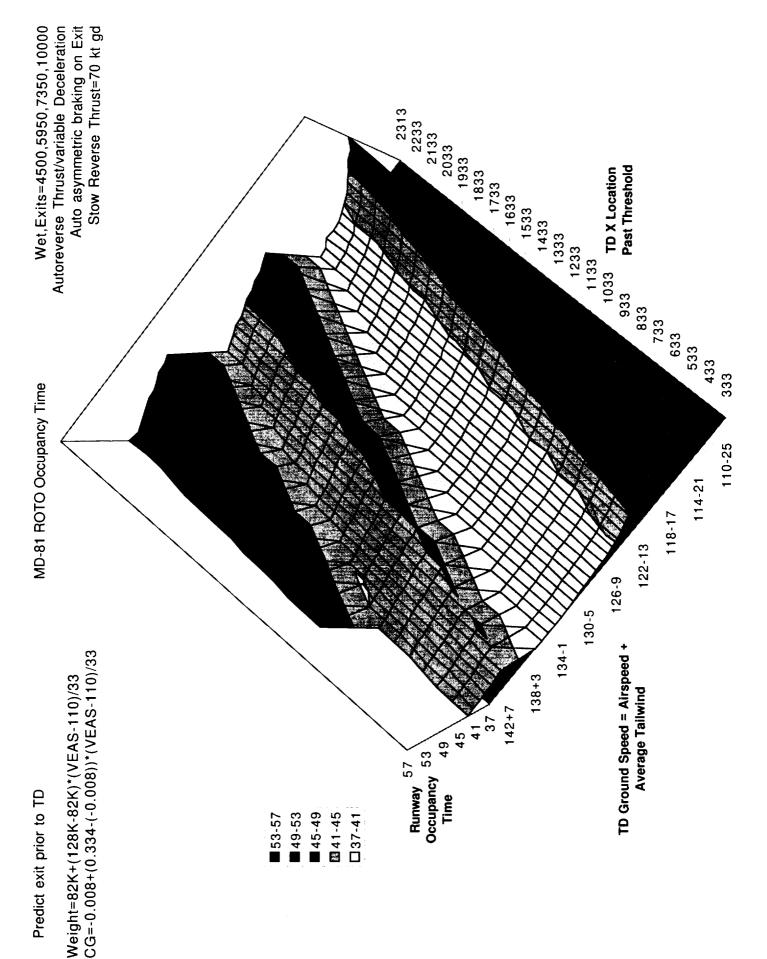
MD-81 ROTO ROT Probability Distribution Dry, Maximum reverse thrust/constant 6.5 decel Mean=41, STDEV=3.735

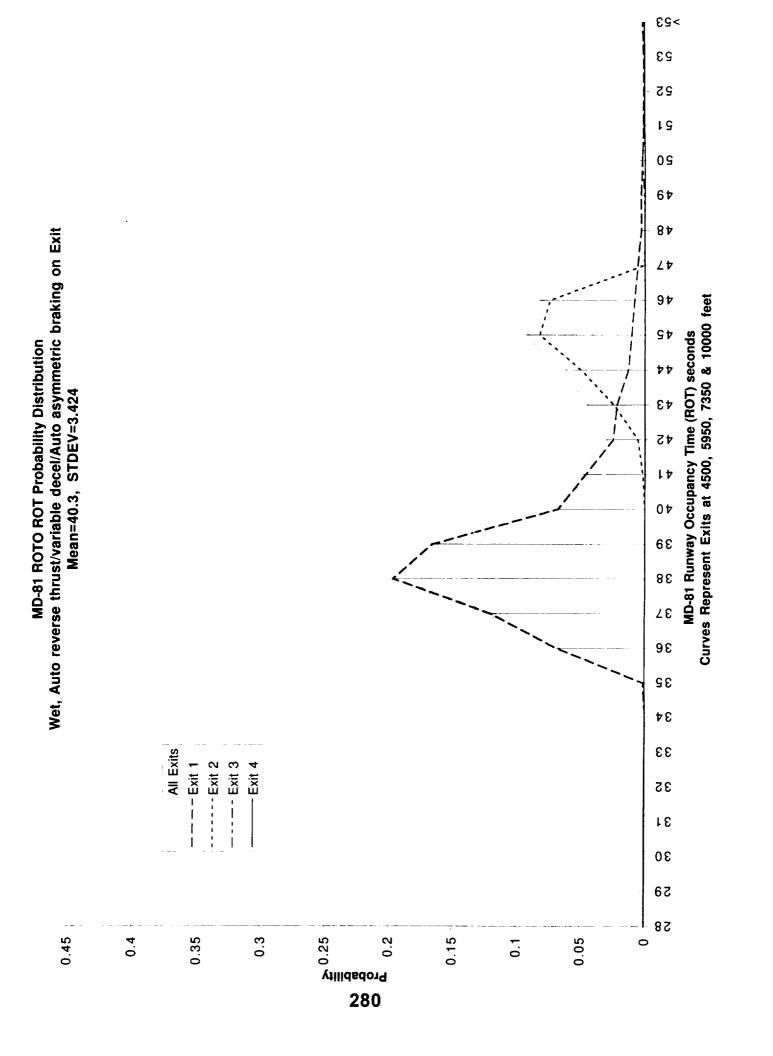


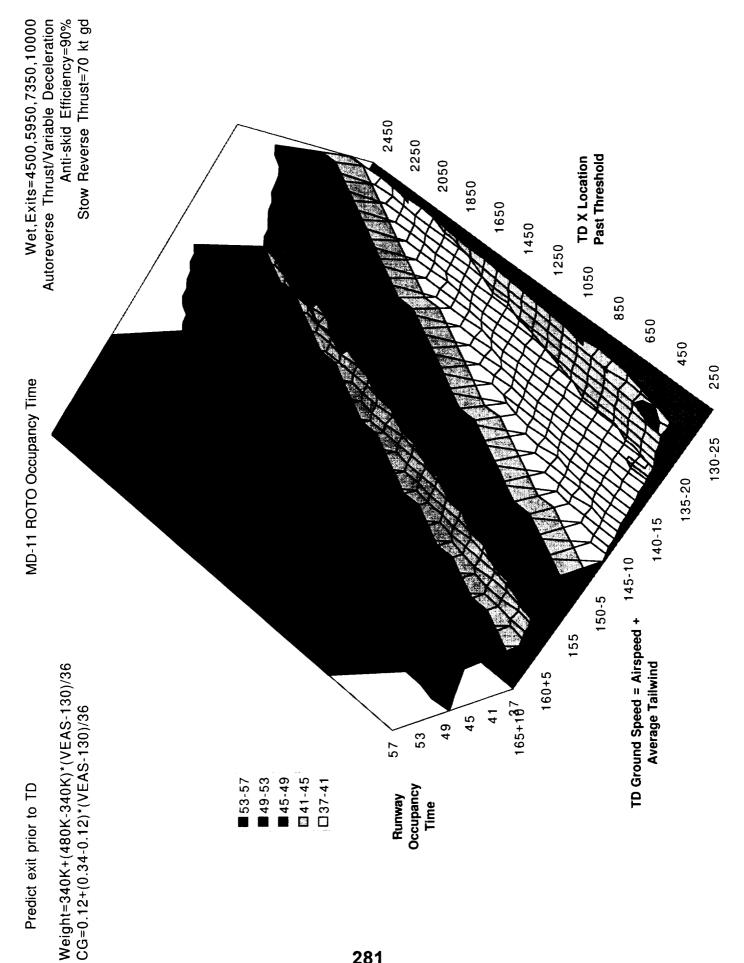


>23 23 25 19 09 6 t 81 Wet, Auto reverse thrust/variable decel/Auto asymmetric braking on Exit Mean=45.7, STDEV=4.25 **۷**۲ 91 97 t t 843 45 17 0 Þ 38 38 2Σ 98 32 All Exits 34 - Exit 4 ----- Exit 2 ---- Exit 3 ----Exit 1 33 35 18 30 58 82 778 Villidadora 0.45 0.4 0.35 0.3 0.15 0.05 0.1 0

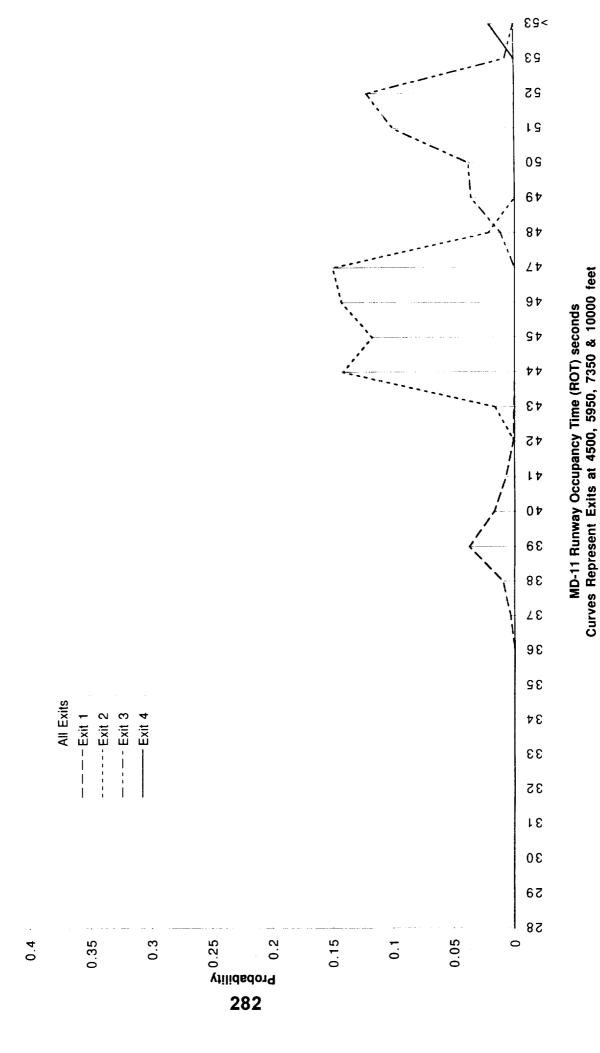
MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 4500, 5950, 7350 & 10000 feet

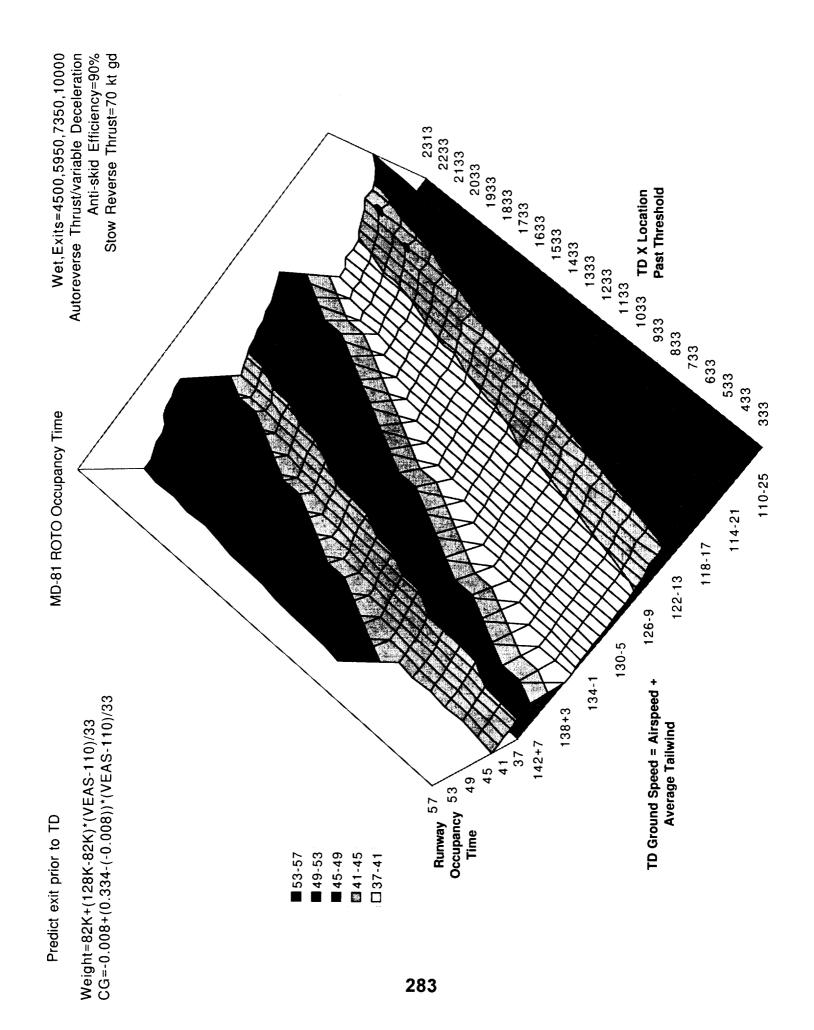




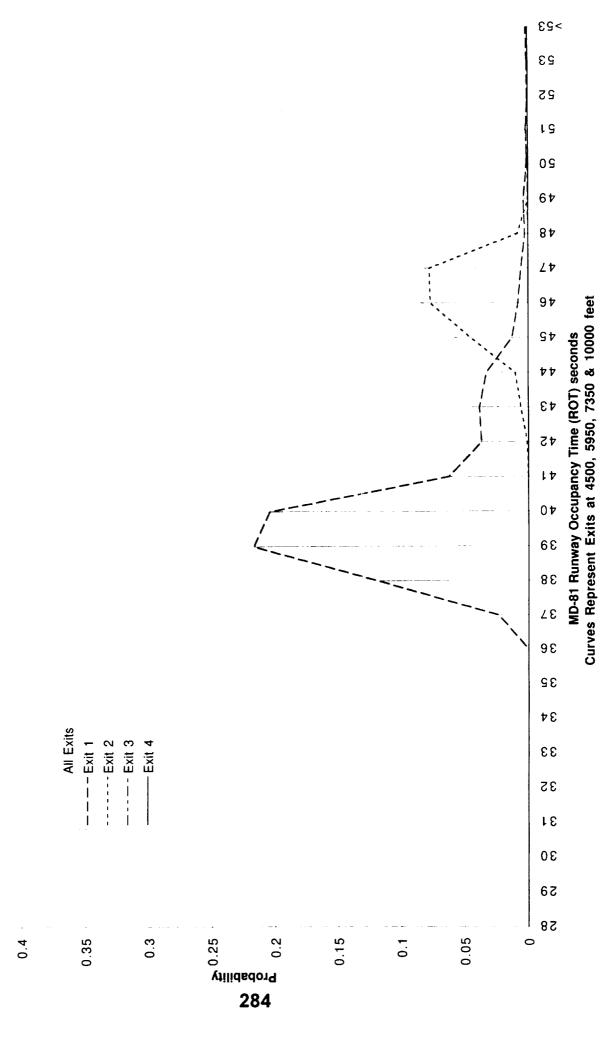


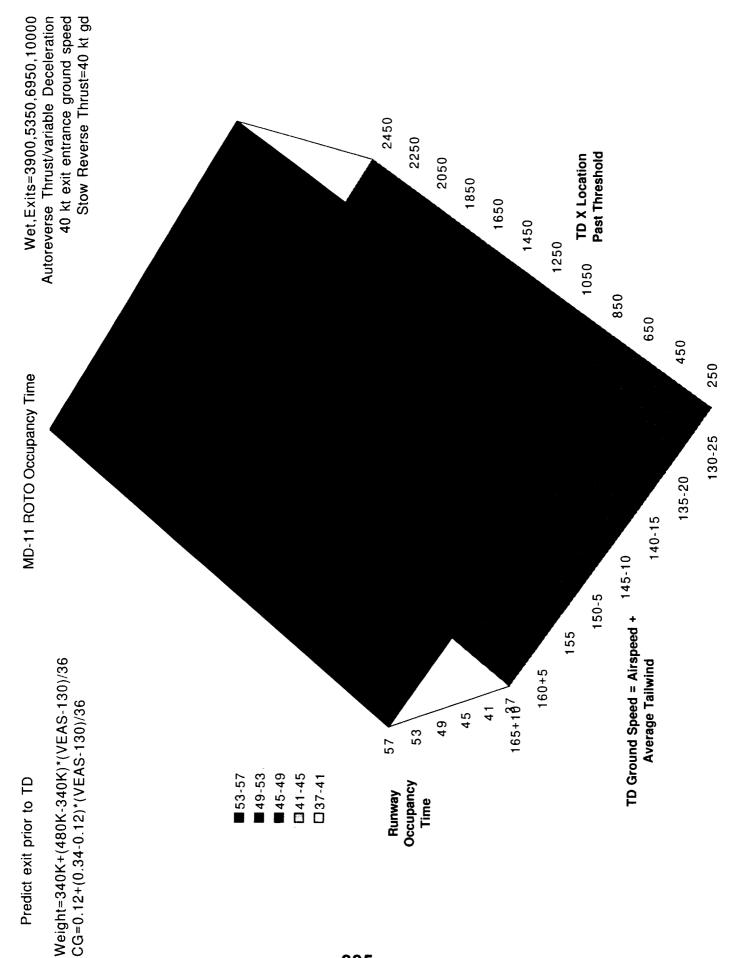
Wet, Auto reverse thrust/variable decel/Anti-skid Efficiency=90% Mean=47.1, STDEV=4.12 **MD-11 ROTO ROT Probability Distribution**





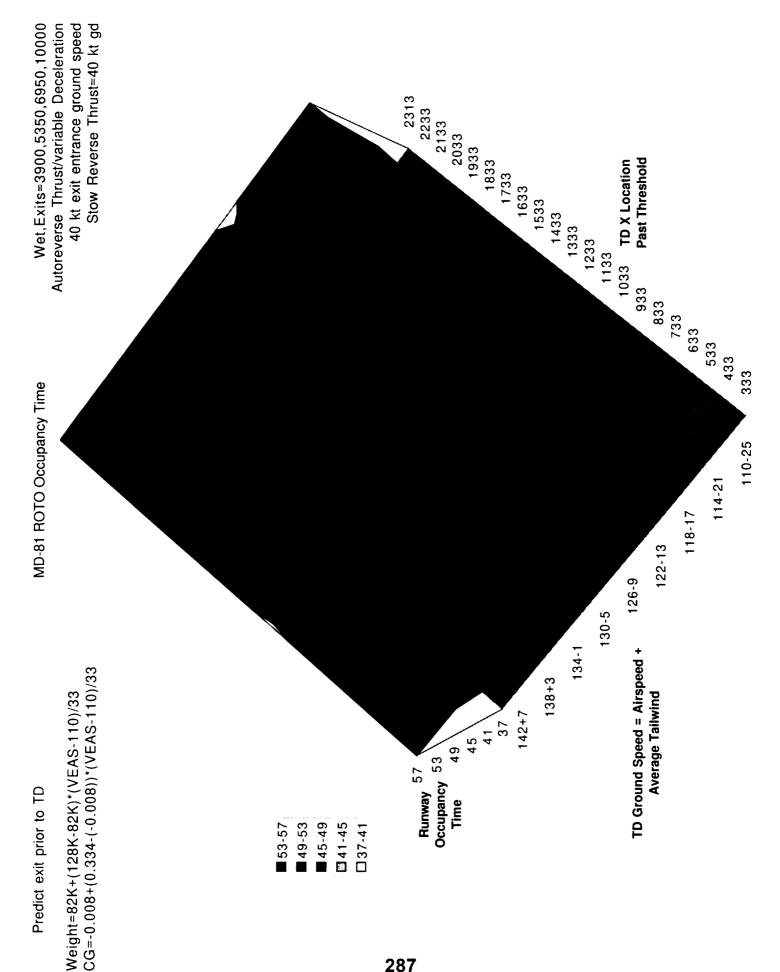
MD-81 ROTO ROT Probability Distribution
Wet, Auto reverse thrust/variable decel/Anti-skid Efficiency=90%
Mean=41.5, STDEV=3.21

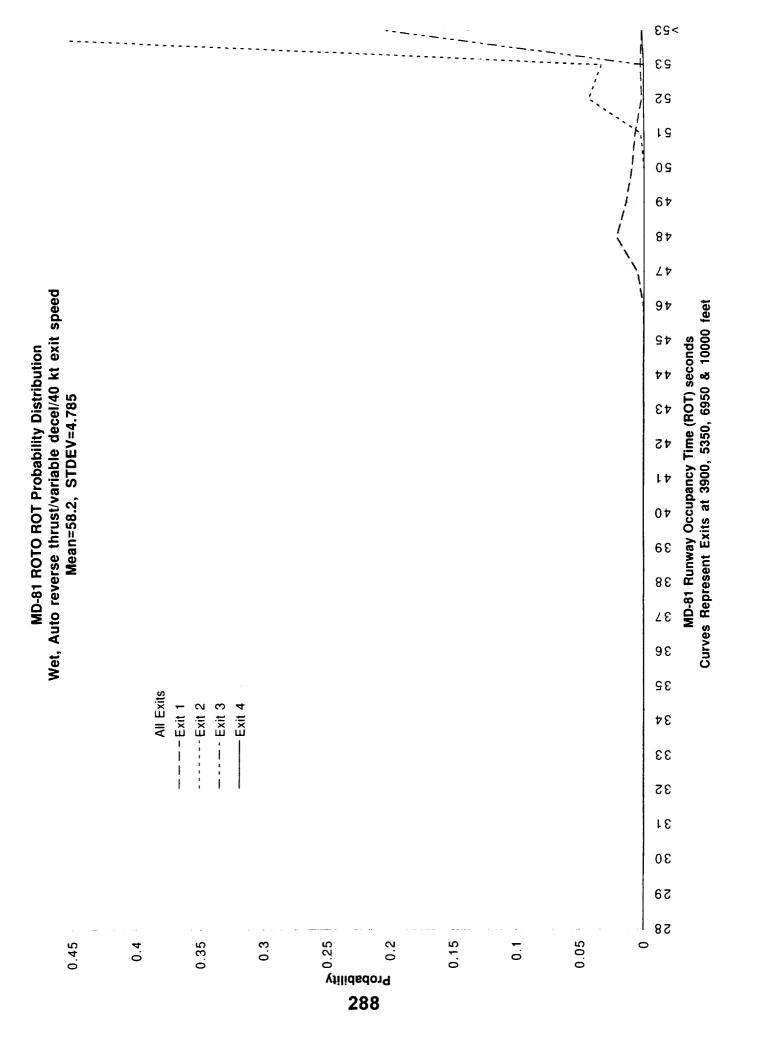




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MD-11 Runway Occupancy Time (ROT) seconds Curves Represent Exits at 3900, 5350, 6950 & 10000 feet





Form Approved OMB No. 0704-0188 REPORT DOCUMENTATION PAGE Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data source gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jeffer (1970), Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503. ts, 1215 Jefferson Davis 3. REPORT TYPE AND DATES COVERED 2. REPORT DATE 1. AGENCY USE ONLY (Leave blank) June 1997 Contractor Report 5. FUNDING NUMBERS 4. TITLE AND SUBTITLE Sensitivity of Runway Occupancy Time (ROT) to Various Rollout and Turnoff (ROTO) Factors, Volume II - Complete C NAS1-19730 Task 10 Set of Plotted Data WU 538-04-13-02 6. AUTHOR(S) S. H. Goldthorpe 8. PERFORMING ORGANIZATION 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) REPORT NUMBER McDonnell Douglas Corporation 2401 E. Wardlow Road CRAD-9206-TR-3306 Long Beach, CA 90807-5309 10. SPONSORING / MONITORING 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) AGENCY REPORT NUMBER National Aeronautics and Space Administration NASA CR-201712, Vol. II Langley Research Center Hampton, VA 23681-0001 11. SUPPLEMENTARY NOTES Langley Technical Monitor: R. M. Hueschen FINAL REPORT 12b. DISTRIBUTION CODE 12a. DISTRIBUTION / AVAILABILITY STATEMENT **Unclassified - Unlimited** Subject Category 08 13. ABSTRACT (Maximum 200 words) The Terminal Area Productivity (TAP) research program was initiated by NASA to increase the airport capacity for transport aircraft operations. One element of the research program is called Low Visibility Landing and Surface Operations (LVLASO). A goal of the LVLASO research is to develop transport aircraft technologies which reduce Runway Occupancy Time (ROT) so that it does not become the limiting factor in the terminal area operations that determine the capacity of a runway. Under LVLASO, the objective of this study was to determine the sensitivity of ROT to various factors associated with the Rollout and Turnoff (ROTO) operation for transport aircraft. The following operational factors were studied and are listed in the order of decreasing ROT sensitivity: ice/flood runway surface condition, exit entrance ground speed, number of exits, high-speed exit locations and spacing, aircraft type, touchdown ground speed standard deviation, reverse thrust and braking method, accurate exit prediction capability, maximum reverse thrust availability, spiral-arc vs. circle-arc exit geometry, dry/slush/wet/snow runway surface condition, maximum allowed deceleration, auto asymmetric braking on exit, do not stow reverse thrust before the exit, touchdown longitudinal location standard deviation, flap setting, anti-skid efficiency, crosswind conditions, stopping on the exit and touchdown lateral offset. 16. NUMBER OF PAGES 14. SUBJECT TERMS Rollout and Turnoff, Runway Occupancy Time, Low Visibility Landing and Surface 290 Operations, Terminal Area Transport Aircraft Operations, Airport Capacity, rollout 16. PRICE CODE and turnoff guidance, Runway Occupancy Time Sensitivity 20. LIMITATION OF ABSTRACT 19. SECURITY CLASSIFICATION 18. SECURITY CLASSIFICATION 17. SECURITY CLASSIFICATION OF ABSTRACT OF THIS PAGE OF REPORT

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